14th Rhythm Production and Perception Workshop

11th – 13th September 2013, University of Birmingham

Programme

Daily Overview:

10th September:

10:00-17:00 Pre-conference workshop: "Measuring Multi-Person Timing: State of the art methods and analyses" (Pre-registered attendees only).

17:30-19:00 RPPW Welcome Drinks & Canapés (Location: Hills Building [R3]).

11th September:

8:00-9:00 Conference Registration

9:00-17:00 Day 1 RPPW

19:30-late RPPW Banquet (San Carlo, Birmingham; included in registration)

12th September:

9:00-18:15 Day 2 RPPW

19:30-late Optional Dinner and Skittles (Location: Selly Oak, Birmingham)

13th September:

9:00-16:00 Day 3 RPPW

16:00-17:00 Tour of the SyMoN Labs

Venues:

Pre-Conference Workshop (10th Sept): Hills Building/Arts Building, University of Birmingham, Edgbaston, B15 2TT. See buildings R3 and R16 on Campus Map respectively.

RPPW Talks, Posters and Lunch: Arts Building, University of Birmingham, Edgbaston, B15 2TT. See building R16 on Campus Map.

Evening Events:

Welcome Drinks & Canapés, 10th September, 17:30-19:00.
Celebrate the beginning of RPPW with an informal early evening wine and canapé event. This will be held in the foyer of the Hills Building (R3).

Banquet at San Carlo, Birmingham, 11th September, 19:30-Late.
The main RPPW evening event is to be held at San Carlo, one of Birmingham's finest Italian restaurants. This meal is included in the registration fee.
4 Temple St, Birmingham, West Midlands B2 5BN,
http://www.sancarlo.co.uk/birmingham

Birmingham Balti at Dilshad or skittles and drinks at the Selly Park Tavern, 12th September, 19:30-late.
An optional evening event, details about this event will be emailed separately.

Organising Committee:

Massimiliano Di Luca
Mark Elliott
Satoshi Endo
Juliane Honisch
Danni Sims
Alan Wing

Contact:

School of Psychology, University of Birmingham, Edgbaston, B15 2TT.

rppw14@gmail.com

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Sponsors:

We thank the following sponsors for financially supporting RPPW:

- Timely COST www.timely-cost.eu
- APDM www.apdm.com
- Qualisys www.qualisys.com

Campus Map:

Edgbaston Campus Map

Index to buildings by zone

Red Zone

- **R1** Law Building
- **R2** Frankland Building
- **R3** Hills Building
- **R4** Aston Webb – A Block, Earth Sciences
- **R5** Aston Webb – B Block
- **R6** Aston Webb – Great Hall
- **R7** Aston Webb – C Block
- **R8** Physics West
- **R9** Nuffield
- **R10** Physics East
- **R11** Medical Physics
- **R12** Bramall Music Building
- **R13** Poynting Building
- **R14** Barber Institute of Fine Arts
- **R15** Watson Building
- **R16** Arts Building
- **R17** Ashley Building
- **R18** Strathcona Building
- **R19** Education Building
- **R20** J G Smith Building
- **R21** Muirhead Tower
- **R22** Main Library
- **R23** University Centre
- **R24** Staff House
- **R25** Munrow Sports Centre
- **R26** Geography
- **R27** Biosciences Building
- **R28** Learning Centre and Primary Care

Blue Zone

- **B1** Medical School
- **B2** Institute of Biomedical Research including IBR West
- **B3** Wellcome Clinical Research Facility (1st floor)
- **B4** Robert Aitken Institute for Clinical Research
- **B5** CRUK Institute for Cancer Studies and Denis Howell Building
- **B6** Research Park
- **B7** 90 Vincent Drive
- **B8** Henry Wellcome Building for Biomolecular NMR Spectroscopy
- **B9** Medical Practice and Dental Centre

Orange Zone

- **O1** The Guild of Students
- **O2** St Francis Hall
- **O3** University House
- **O4** Elm House

Green Zone

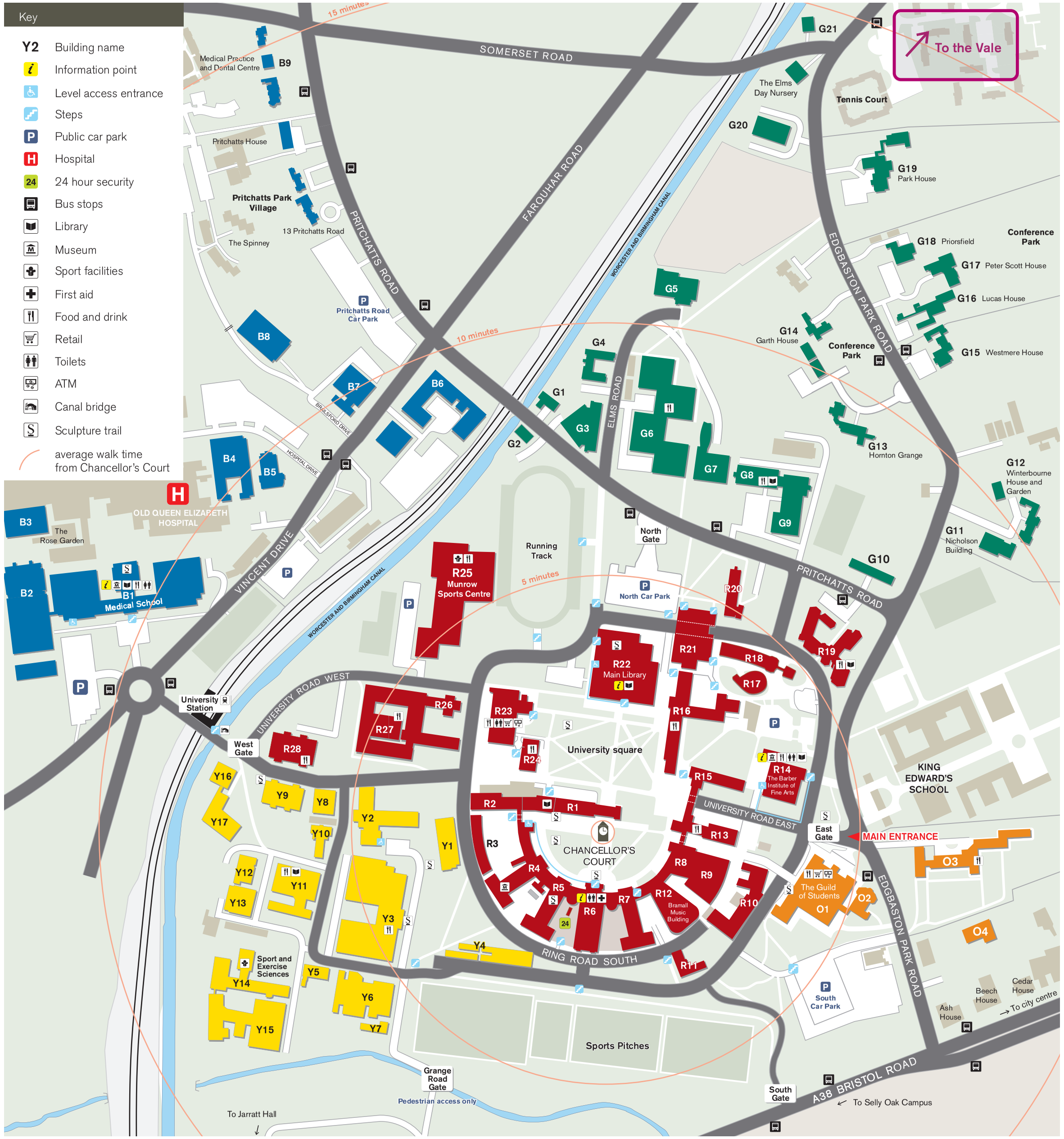
- **G1** 32 Pritchatts Road
- **G2** 31 Pritchatts Road
- **G3** European Research Institute
- **G4** 3 Elms Road
- **G5** Computer Centre
- **G6** Metallurgy and Materials
- **G7** IRC Net Shape Laboratory
- **G8** Gisbert Kapp Building
- **G9** 52 Pritchatts Road
- **G10** 54 Pritchatts Road
- **G11** Nicholson Building
- **G12** Winterbourne House and Garden
- **G15** Westmere
- **G18** Priorsfield
- **G19** Park House
- **G20** Elms Plant
- **G21** Park Grange
- **G22** Elms Day Nursery

Green Zone Conference Park

- **G13** Hornton Grange
- **G14** Garth House
- **G16** Lucas House
- **G17** Peter Scott House

Yellow Zone

- **Y1** Old Gymnasium
- **Y2** Haworth Building
- **Y3** Mechanical and Civil Engineering Building
- **Y4** Terrace Huts
- **Y5** Estates West
- **Y6** Maintenance Building
- **Y7** Grounds and Gardens
- **Y8** Chemistry West
- **Y9** Computer Science
- **Y10** Alta Bioscience
- **Y11** Chemical Engineering
- **Y12** Biochemical Engineering
- **Y13** Chemical Engineering Workshop
- **Y14** Sport and Exercise Sciences
- **Y15** Civil Engineering Laboratories
- **Y16** Occupational Health
- **Y17** Public Health



Dilshad

Selly Park Tavern

RPPW 14, Full Events Programme

Day 1, 11th September 2013

Time	Session	Presenter
8:00-9:00	Registration	
9:00-9:40	Welcome and Introduction	Wing, A. Elliott, M.
9:40-10:40	Talk Session 1: Perception I	
	T1.1 Temporal context mediates the effect of movement on perceived timing	Manning, F. Schutz, M.
	T1.2 Can zebra finches distinguish between interval-based and beat-based rhythms?	van der Aa, J. Honing, H. Cate, C.
	T1.3 Five-year-old children's beat perception and beat synchronization abilities	Einarson, K. Trainor, L.
10:40-11:10	Refreshments	
11:10-12:10	Talk Session 2: Perception II	
	T1.4 Do you remember the time? Working memory for time interval structure	Teki, S. Griffiths, T.
	T1.5 Construction of a time awareness scale: A measurement of individual differences in everyday temporal perception	Rowe, K. Duggan, K. McDevitt, E. Mednick, S.
	T1.6 Bayesian perception of isochronous rhythms	Rhodes, D. Di Luca, M.
12:10-12:35	1 minute poster presentations	See Poster Session 1
12:35-14:20	Lunch and Poster Session 1: P1.1-P1.14	See Poster Session 1
14:20-15:40	Talk Session 3: Modelling	
	T1.7 Parameter estimation of sensorimotor synchronization models.	Jacoby, N. Keller, P. Repp, B.
	T1.8 Stochastic methods for the simulation of micro-timing variation in rhythmic performance	Stables, R.
	T1.9 Modelling synchronization in musical ensemble playing: Parameter estimation and sensitivity to assumptions.	Vorberg, D. Schulze, H.
	T1.10 Hierarchical Bayesian models for analysis of isochronous sensorimotor synchronization data	Baath, R.
15:40-16:00	Refreshments	
16:00-17:00	Invited Speaker Talk	
	T1.11 Long-range correlations in temporal sequences – designing auditory cues for locomotion	Daffertshofer, A.
17:00	Day 1 Close	
19:30-Late	Evening Banquet (Venue: San Carlo, Birmingham)	

Day 2, 12th September 2013

Time	*Session*	*Presenter*
9:00-10:20	**Talk Session 4: Neuroscience and Imaging**	
	T2.1 Knowing the score: How does familiarity with a co-performer's part affect temporal coordination in musical ensembles?	Keller, P. Uhlig, M. Novembre, G.
	T2.2 Scrutinizing subjective rhythmization: A combined ERP/oscillatory approach	Obermeier, C. Kotz, S.
	T2.3 From sounds to movement and back: How movement shapes neural representation of beat and meter	Nozaradan, S. Peretz, I. Mouraux, A.
	T2.4 How much beat do you need? An EEG study on the effects of attention on beat perception using only temporal accents	Bouwer, F. Honing, H.
10:20-10:50	**Refreshments**	
10:50-11:50	**Invited Speaker Talk**	
	T2.5 Functional neuroanatomy of directing attention in time	Coull, J.
11:50-12:15	**1 minute poster presentations**	See Poster Session 2
12:15-14:00	**Lunch and Poster Session 2: P2.1-P2.12**	See Poster Session 2
14:00-15:00	**Talk Session 5: Speech and Language I**	
	T2.6 "Rhythms for bears to dance to": Communicative function and prosodic form in speech timing	White, L.
	T2.7 The role of dialect-specific vowel duration in lexical access	Smith, R. Rathcke, T.
	T2.8 Rhythmic constraints on read and rapped speech	Anbari, S. Wlodarczak, M. Wagner, P.
15:00-15:20	**Refreshments**	
15:20-16:00	**Talk Session 6: Speech and Language II**	
	T2.9 The role for auditory rhythm processing in phonological language and literacy skills	Grube, M. Kumar, S. Cooper, F. Davison, C Griffiths, T.
	T2.10 Rhythm processing in stuttering and non-stuttering children	McAuley, D. Wieland, E. Dilley, L. Chang, S.
16:00-18:15	**Applications of Rhythm Production Perception**	
	T2.11 Conducting: Is timing really the be all and end all?	Watson, D.
	T2.12 Demonstration of Birmingham Electro-Acoustic Sound Theatre (BEAST). *Venue: Bramall School of Music (R12 Campus Map)*	Wilson, S.
18:15	**Day 2 Close**	
19:30-Late	**Optional Dinner and Social Event (Curry and Skittles)**	

Day 3, 13th September 2013

Time	Session	Presenter
9:00-10:20	**Talk Session 7: Music**	
	T3.1 Rhythm, movement and the groove connection - what is it good for?	Madison, G.
	T3.2 Slowness in music performance and perception: and analysis of timing in Feldman's "Last Pieces"	Moelants, D.
	T3.3 Timing and synchronisation of professional musicians: a comparison between orchestral brass and string players	Fischinger, T.
	T3.4 It's all in the wrist: Neural substrates of rhythmic timing in young and older professional musicians and controls	Krampe,R. Wenderoth, N. Lavrysen, A. Swinnen, S
10:20-10:50	**Refreshments**	
10:50-12:10	**Talk Session 8: Movement I**	
	T3.5 Video-based motion capture application to characterising rhythmic activities in single or multiple human targets	Zheng, F. Brownjohn, J. Racic, V. Elliott, M.
	T3.6 Synthesis of asymmetric movement trajectories by means *of* frequency modulation	Waadeland, C.
	T3.7 The impact of cerebellar and basal ganglia dysfunction on the accuracy and variability of motor timing	Jones, C. Claassen, D. Yu, M. Dirnberger, G., et al.
	T3.8 Interpersonal motor synchrony to a musical beat as a cue for social cohesion during infancy	Cirelli, L. Einarson, K. Lade, S. Trainor, L
12:10-13:30	**Lunch and Business Meeting***	*RPPW Committee Current/Previous Organisers
13:30-14:10	**Talk Session 9: Movement II**	
	T3.9 Moving to the beat. Analysing motion responses to different pulse shapes	Danielsen, A. Haugen, M. Jensenius, A.
	T3.10 The spatial-tapping task to reveal the coexistence of event-based and emergent timing for the control of rhythmic sequences	Dione, M. Ott, L. Delevoye-Turrell,Y.
14:10-15:10	**Invited Speaker Talk**	
	T3.11 Enculturation, Learning and Plasticity in the Development of Rhythm Perception & Entrainment	Trainor, L.
15:10-15:30	**Refreshments**	
15:30-16:00	**RPPW 14 Concluding Discussion**	
	Closing Remarks (inc., presentation of meeting budget and vote/announcement of next venue)	Wing, A. Elliott, M.
16:00-17:00	**Tour of the SyMoN Labs (with wine and nibbles)**	
17:00	**RPPW 13 Close**	

Poster Session Programme

Poster Session 1 – Day 1

	Topic	Presenter
	Poster Topic: Perception	
P1.1.	Using EEG with children and adults to measure oscillatory activity in response to isochronous auditory sequences	Cirelli, L. Ghahremani, A. Manning, F. Spinelli, C. Marie, C. Bosnyak, D. Fujioka, T. Trainor, L.
P1.2.	How do non-auditory senses contribute to rhythm perception?	Cullen, C.
P1.3.	A duel-task approach to study temporal preparation induced by auditory and visual rhythms	Cutanda, D. Correa, A. Sanabria, D.
P1.4.	Impaired numerical ability affects supra-second time perception	Gilaie-Dotan, S. Rees, G. Butterworth, B. Cappelletti, M.
P1.5.	Temporal preparation contributes to the overestimation of duration of 'oddball' events	Fromboluti, E.K., Jones, K.B., McAuley, J.D.
P1.6.	Stretching Time: The effects of a pharmaceutical sleep aid on time perception	Rowe, K. McDevitt, E. Cellini, N. Duggan, K. Mednick, S.
P1.7.	Prediction of event valence by time of occurrence: A case of anticipative emotion regulation	Thomaschke, R. Dreisbach, G.
	Poster Topic: Modelling	
P1.8.	Rhythm pattern theory and a binary rhythm pattern indexing system	Aldridge, D.
P1.9.	Statistical table for the Wing & Kristofferson model	Larue, J.
	Poster Topic: Movement I	
P1.10.	Interactions of force and time control investigated through state transitions	Chua, W. Maij, F. Wing, A.
P1.11.	Synchronisation and continuation during a dance act	Sgouramani, H. Muller, C. Noorden, L. Leman, M. Vatakis, A.
P1.12.	Seeing the bounce, hearing the beat: Effects of periodic visual biological motion on the perception of auditory rhythms.	Su, Y
P1.13.	Behavioural asynchrony taints the interaction context	Honisch, J. Quinn, K. Cacioppo, J.
P1.14.	Can dancers suppress the haptically mediated inter-personal synchrony during voluntary periodic sway?	Sofianidis, G. Hatzitaki, V. Elliott, M., Wing, A.

Poster Session 2 – Day 2

	Topic	Presenter
Poster Topic: Neuroscience and Imaging		
P2.1.	Stages of beat perception and the influence of incongruity: An fMRI study	Cameron, D. Grahn, J.
P2.2.	Auditory-motor synchronisation amplifies the effects of periodicity on auditory deviance processing: a P300 study	Schmidt-Kassow, M. Heinemann, L. Abel, C. Kaiser, J.
Poster Topic: Speech and Language		
P2.3.	Motor timing in dyslexia: Evaluating findings to date to reappraise the neural basis of timing impairments	Birkett, E.
P2.4.	Prosodic structure and cycling in Greek and Korean	Chung, Y. Ritchart, A. Arvaniti, A.
P2.5.	Longitudinal trends in pause distributions in spoken texts	Quene, H.
P2.6.	Cross-linguistic analysis of speech rhythm with decomposition of the amplitude envelope	Tilsen, S. Arvaniti, A.
Poster Topic: Movement II		
P2.7.	Many Moving as One? Analyses of movement synchrony in large groups.	Elliott, M., Zheng, F., Racic, V., Brownjohn, J.M.W., Wing, A.M.
P2.8.	Processing demands during the performances of rhythmic motor sequences	Hestermann, L D. Wagemans, J. Krampe, R.
Poster Topic: Music		
P2.9.	Tempo in baroque music and dance	Coorevits, E. Moelants, D.
P2.10.	The significance of verticality for musical entrainment	Zeiner-Henriksen, H.
P2.11.	Exploring beat processing as a link between musical training and speech-in-noise perception	Yates, K. Amitay, S. Moore, D. Shub, D. Barry, J.
P2.12.	ESP: ensemble synchronisation perception	Yates, T. Endo, S. Wing, A.

Oral Presentations

T1.1 Temporal Context Mediates the Effect of Movement on Perceived Timing

Fiona Manning* and Michael Schutz
McMaster University, Hamilton, ON
Email: manninfc@mcmaster.ca

The context in which rhythmic sequences occur is an important factor that influences perceived timing (Jones, Boltz, & Kidd, 1982; McAuley & Jones, 2003; Repp, 2002). Previously we demonstrated that motion improved timing judgments of a tone that followed a period of silence (Manning & Schutz, *in press*). In the present set of studies, we manipulated the context in which these temporal deviations occurred. Participants listened to an isochronous sequence of beats and identified the timing of a final probe tone. They either tapped along to the beats or listened while remaining still. In one experiment the probe tone occurred immediately after the sequence (i.e., without an embedded period of silence). In additional experiments the probe tone was separated from the sequence using a silence equivalent to the duration of one, two or three beats. When the silent period was absent, movement hindered timing judgments if the probe tone occurs earlier than expected. When the probe tone was on-time or late, there was no difference in performance between movement and no-movement conditions. When any period of silence separated the probe tone from the sequence, movement facilitated timing judgments. This finding sheds light on the role of rhythmic context in timing judgments and, in particular, demonstrates the role of motion for timekeeping through silence.

T1.2 Can zebra finches distinguish between interval-based and beat-based rhythms?

Jeroen van der Aa[1*], Henkjan Honing[2] & Carel ten Cate[1]
1) Behavioural Biology, Institute of Biology Leiden, Leiden University, The Netherlands
2) Cognitive Science Center Amsterdam, Institute for Logic, Language and Computation, University of Amsterdam, The Netherlands
Email: jeroen.vdaa@hotmail.com

Beat induction, which is thought to be a fundamental trait of musicality and conditional to the origins of music (Honing & Ploeger, 2012), is suggested to be dependent on vocal learning (Patel, 2006). All evidence gathered thus far is in agreement with this hypothesis. All species showing evidence of beat induction are vocal learners (e.g. Schachner et al., 2009) and the neural networks underlying vocal learning and beat induction show large overlap in humans. However, the only non-human animal which has unequivocally been shown to display genuine beat induction is Snowball, a sulphur-crested cockatoo (*Cacatua galerita eleonora*; Patel et al., 2009), all other evidence is still open ended and can be explained by other mechanisms than beat induction. We examine beat induction in zebra finches (a vocal learning songbird; *Taeniopygia guttata)* in experiments on rhythm and beat perception using a Go/No-go paradigm. In these experiments, zebra finches have learned to discriminate strings of sound pulses organized according to regular and irregular patterns. The experiments are currently in progress with the RPPW being the appropriate platform to present the results.

References

Honing, H., & Ploeger, A. (2012). Cognition and the evolution of music: Pitfalls and prospects. *Topics in Cognitive Science*, *4*, 513–524. doi:10.1111/j.1756-8765.2012.01210.x

Patel, A. D. (2006). Musical rhythm, linguistic rhythm, and human evolution. *Music Perception*, *24*, 99–104.

Patel, A. D., Iversen, J. R., Bregman, M. R., & Schulz, I. (2009). Studying synchronization to a musical beat in nonhuman animals. *Annals of the New York Academy of Sciences*, *1169*, 459–469. doi:10.1111/j.1749-6632.2009.04581.x

Schachner, A., Brady, T. F., Pepperberg, I. M., & Hauser, M. D. (2009). Spontaneous motor entrainment to music in multiple vocal mimicking species. *Current Biology*, *19*, 831–836. doi:10.1016/j.cub.2009.03.061

T1.3 Five-year-old Children's Beat Perception and Beat Synchronization Abilities

Kathleen M. Einarson & Laurel J. Trainor
McMaster University, Hamilton, Canada
Email: einarsk@mcmaster.ca

Western adults without formal training have implicit knowledge of their culture's music (e.g., Hannon & Trainor, 2007). Even though simple metres are much more common than complex meters in Western music (London, 1995), young infants appear equally sensitive to both (Hannon & Trehub, 2005). Evidence of enculturation can be seen by 12 months, and adults perceive and reproduce rhythms with simple metrical structures more accurately than complex metres (Hannon & Trehub, 2005; Snyder et. al, 2006). We examined five-year old children's perceptual sensitivity to musical beat alignment (adapting the adult task of Iversen & Patel, 2008), the degree to which children synchronized their tapping to the beat of music with simple or complex metres (adapting the adult task of Iversen & Patel, 2008), and whether beat production abilities correlate with perceptual sensitivity.

Children were presented with pairs of videos of puppets drumming to music with simple or complex metre. One puppet's drumming was synchronized with the beat of the music and the other had either incorrect tempo (10% faster or slower) or incorrect phase (25% early or late). Children were asked to select the better drummer. Children then tapped on an electronic drum at a self-paced speed, with a metronome, and with musical excerpts. Five-year-olds were better able to detect beat misalignments in simple than in complex metre music for both phase errors (p= .047) and tempo errors (p= .003). Error detection for complex metres was not significantly above chance (p= .73). Tapping synchronization is less affected by metric structure.

T1.4 Do you remember the time? Working memory for time interval structure

Teki S1,2, Griffiths TD1,2
1Wellcome Trust Centre for Neuroimaging, University College London
2Auditory Cognition Group, Institute of Neuroscience, Newcastle University
Email: sundeep.teki@gmail.com

Time perception research is flourishing but work on the representation of time intervals into memory is limited. Previous work has addressed this question based on a categorical task which requires the discrimination of two time intervals separated by a gap (Rao et al., 2011; Coull et al., 2008).

In this work, I aim to investigate the brain bases of memory for time intervals and the underlying neuronal mechanisms using a novel time matching paradigm based on a dynamic resource allocation model of working memory (Bays and Husain, 2008). I characterized the precision of memory for a single interval in different sequences of – a) 4 intervals with IOI in the range 500-600ms; b) 4 intervals with IOI in the range 1000-1200 ms; c) 1-4 intervals with sub-second IOI; d) 4 intervals where the interval to be reproduced was cued (Teki and Griffiths, 2012). The behavioral results suggest that memory for a single interval depends critically on the context and it decreases with increasing jitter, IOI and number of intervals in the sequence and is invariant to attentional cueing. I will present results from an ongoing sparse functional MRI experiment designed to examine the brain substrates involved in encoding memory for time intervals. A parametric analysis will be performed to look for areas that encode time intervals into memory as a function of jitter and working memory load with an *a priori* hypothesis for a critical role for the basal ganglia, cerebellum and the prefrontal cortex (cf Teki et al., 2011; 2012).

References

1. Coull, J.T., Nazarian, B., and Vidal, F. (2008). Timing, storage, and comparison of stimulus duration engage discrete anatomical components of a perceptual timing network. J Cogn Neurosci *20*, 2185–2197.

2. Rao, S.M., Mayer, A.R., and Harrington, D.L. (2001). The evolution of brain activation during temporal processing. Nat. Neurosci. *4*, 317–323.

3. Teki S,. Griffiths, T.D. (2012). On the nature of rhythm, time and memory. Abstract presented at the Annual Meeting of the Society for Neuroscience

4. Teki, S., Grube, M., Kumar, S., and Griffiths, T.D. (2011). Distinct neural substrates of duration-based and beat-based auditory timing. J. Neurosci. *31*, 3805–3812.

5. Teki, S., Grube, M., and Griffiths, T.D. (2012). A unified model of time perception accounts for duration-based and beat-based timing mechanisms. Front. Integr. Neurosci. *5*, 90

T1.5 Construction of a Time Awareness Scale: A Measurement of Individual Differences in Everyday Temporal Perception

Kelly M. Rowe, Katherine A. Duggan, Elizabeth A. McDevitt, Sara C. Mednick
Department of Psychology, University of California, Riverside, CA
Email: kellymorganrowe@gmail.com

Individual differences in time perception have been associated with cognitive deficits, working memory capacity and emotional regulation. Typical laboratory tasks measure time perception in durations ranging from milliseconds to minutes. Currently there is no validated tool for measuring how time is perceived outside these short durations. We are developing and validating a self-report scale that assesses individual differences in time perception across a variety of contexts and populations. Specifically, this instrument will provide a trait measure of time awareness - a person's intrinsic knowledge of objective time in their daily lives. This self-report measure will allow: 1) high ecological validity; 2) concise and easy administration in laboratory and naturalistic settings; 3) reliable estimates of time awareness across time; and 3) improved understanding of the relationship between time perception capabilities and related constructs (e.g. temporal discriminations vs. estimation bias).

The first wave of scale development will evaluate candidate sub scales including: variability in perceived durations, estimation biases, time estimation accuracy, sensitivity to external temporal cues, reliance on time sources, prospective memory, and time management. We will create and administer normal and reverse scored items for each of the aforementioned temporal constructs. Healthy participants will be tested at four time points to assess test-retest reliability of this instrument, and scale items will be compared to performance outcomes on a variety of time perception tasks to ensure criterion validity. Principal components analysis will be used to determine distinct contributions for each of the sub scales and items. Preliminary findings will be discussed.

T1.6 Bayesian perception of isochronous rhythms

Darren Rhodes, Massimiliano Di Luca
University of Birmingham
Email: dxr238@bham.ac.uk

Isochronous sequences create rhythmic expectations about future stimuli. We investigated how expectations can affect the perception of stimuli that appear ‘off-time’.

We presented a sequence of unimodal stimuli (either sounds or lights) with the last stimulus appearing either ‘on-time’ or ‘off-time’. Participants judged whether the last stimulus was isochronous or not: anisochronies were detected easier with longer sequences, but only for stimuli appearing earlier than expected. In another experiment, participants judged whether the last stimulus in the rhythm appeared before or after a temporal probe in another modality. The perceived timing of an anisochronous stimulus was manipulated by whether the stimulus appeared early or later than expected.

Regular sequences affect individual stimuli so that as the number of prior stimuli increases, the perceived time of the last stimulus is shifted towards expectation, while any perceived anisochrony becomes more detectable. We modelled these effects using a Bayesian framework: the expectation of when a stimulus is to occur (prior distribution) is combined with sensory evidence (likelihood function) to give rise to perception (posterior distribution). If a stimulus is not presented when expected, its perceived timing is modified by the rhythmic expectations of the prior probability: the difference between prior and posterior becomes more noticeable as the prior sharpens up with longer sequences.

Acknowledgments: We are grateful to Sofia Hussain and Stephanie Mason for conducting some of the experiments. This research has been funded by FP7-PEOPLE-2011-CIG 304235 ‘TICS’.

T1.7 Parameter estimation of sensorimotor synchronization models

Nori Jacoby, Peter Keller and Bruno Repp
Hebrew University and Bar Ilan University
Email: nori.viola@gmail.com

Linear models have been used in several contexts as models for sensorimotor synchronization. An important practical question, therefore, is how to fit the models' parameters to experimental data. This is important, since these parameters are often linked to psychological processes of interest, such as phase correction and period correction. We compare several methods of parameter estimation using simulations and experimental data. Our results indicate that the efficiency of the highly successful method developed by Vorberg and Schulze (2002) can be improved using several theoretical algorithmic observations, resulting in an estimation process that is faster by more than two orders of magnitude, as verified by our extensive simulations. We compare this method with a novel method (bGLS) proposed in Repp, Keller and Jacoby (2011), and show that the bGLS method is even faster and more general (as it is not uses simulation in the parameter estimation process) while nevertheless giving comparably accurate estimations. We also demonstrate how both methods suffer from parameter interdependence (already acknowledged by Vorberg and Schulze), which limits the accuracy of the parameter estimation process. This problem results from the mathematical structure of linear models, and therefore limits the accuracy of any such method of parameter estimation. We show how this problem can be resolved using further constraints on the parameter space, and finish by suggesting practical applications for these methods on real experimental data.

T1.8 Stochastic methods for the simulation of micro-timing variation in rhythmic performance

Ryan Stables
Birmingham City University
Email: ryan.stables@bcu.ac.uk

In the production of popular music, it is often desirable to emulate the temporal characteristics of a musician. This can lead to the enhancement of musicality and the removal of perceptually synthetic elements from a synthesized signal. In the digital audio workstation this effect is often achieved through the application of normally distributed pseudorandom variates to various elements of the signal. Whilst this type of modulation increases the variability of the musical signal, it does not necessarily increase the human-like naturalness.

In this study we investigate ways in which probabilistic models can be used to simulate the micro-timing variation in individual rhythmic performances and we consider ways in which these models can be adapted to account for group synchronization. To implement this we apply two data-driven techniques, namely a Hidden Markov Model and a Bayesian Model to percussive sequences in order to dynamically derive empirical probability distributions. Onset modulation is then applied using rejection sampling and the sequences are evaluated against existing techniques and human performers using the MUSHRA methodology.

After a series of subjective tests, our results show that the empirically developed models outperform existing models significantly and perform similarly to human performers when evaluated for musicality and naturalness. Here, the sequences generated using the HMM were perceived to be the most similar to a human percussionist and the most musical. We conclude that the stochastic models are capable of reproducing the temporal characteristics of a human performer with a high degree of perceptual significance.

T1.9 Modeling synchronization in musical ensemble playing: Parameter estimation and sensitivity to assumptions.

Dirk Vorberg (WWU Münster) & Hans-Henning Schulze (PhU, Marbeurg)
Email: d.vorberg@uni-muenster.de

An extension of the duet synchronization model (Vorberg, RPPW10, Aldenbiezen) to string quartet performance has been proposed and applied successfully to repeated performances of the same musical section from a Haydn string quartet (Wing et al., RPPW12, Leipzig). Extending the model to ensembles of arbitrary size, we employed Monte Carlo techniques to study its sensitivity to departures from the assumptions (e.g., correction gains changing with beats within bars, negative dependence introduced by motor delays), compared different parameter estimation and goodness of fit measures, and tried to assess how well parameters can be recovered from the limitations given under realistic conditions (small samples of -short times series).

T1.10 Hierarchical Bayesian Models for Analysis of Isochronous Sensorimotor Synchronization Data

Rasmus Bååth
Lund University Cognitive Science
Email: rasmus.baath@lucs.lu.se

Two of the most common measures analyzed in an isochronous sensorimotor synchronization task is constant error and timing variability. A straight forward way to estimate these measures is to calculate the sample mean and sample variance of the tone-to-tap asynchronies. However straight forward and common this approach is it does not necessary generate the most accurate estimates. When the tempo of the pacing tones is slow it is possible to show that using the sample mean and sample variance will regularly underestimate both the constant error and the timing variance. This is because the distribution of the asynchronies becomes increasingly skewed and non-normal as participants start producing reactive responses rather than anticipating responses at long inter stimulus intervals (>2000 ms). Bayesian statistics is an increasingly popular statistical method in psychology that facilitates modeling the non-normal asynchrony distribution arising at slow tempi. By using hierarchical Bayesian modeling estimates can be further improved in the common situation where an experiment involves multiple participants. A hierarchical Bayesian model was implemented using a censored normal distribution to model the distribution of timing asynchronies. Estimates made by the model were compared with the classical methods of estimating constant error and timing variability both using simulated data and experimental data from Repp & Doggett (2007). Using the Bayesian hierarchical model resulted in considerable less bias at slow tempo and outperformed classical methods with regards to accuracy. A freely available implementation of the model in the R programming language is available at
https://github.com/rasmusab/bayes_timing.

T1.11 Long-range correlations in temporal sequences – designing auditory cues for locomotion

Andreas Daffertshofer,
MOVE Research Institute Amsterdam, VU University Amsterdam, The Netherlands
Email: a.daffertshofer@vu.nl

The temporal correlation structure of consecutive events may contain valuable information about the functional organization of the dynamics generating these events. The presence of power law distributions or *1/f noise*, in systems diverse as neural activity in cortex and muscle, or even kinematics is considered a generic marker of healthy and adaptive performance. Many experimental studies provided evidence that (persistent) long-range correlations change with task and environmental constraints. Clinical studies have successfully linked temporal correlation structures of motor events to (the severity of) different pathologies like Huntington's and Parkinson's disease. With respect to the latter, auditory cueing is often assumed beneficial for gait stability. Stride length, cadence, and speed can increase, whereas inter-stride variability and occurrence of freezing decrease when patients are 'paced' by a metronome. Isochronous auditory cues may alter the typical fractal dynamics of healthy gait, and persistent long-range correlations in stride intervals of self-paced gait can even switch to anti-persistent correlations. This qualitative change of gait dynamics may be indicative of 'local' (*i.e.* short-term) coupling processes, allowing for cycle-by-cycle entrainment of motor events with the metronome though this is still speculative. Yet, the literature remains inconclusive about the effect of (isochronous) cueing on gait dynamics. We here discuss whether a train of auditory cues with more fractal-like correlation structure can yield a more consistent and predictable adaptation of motor performance. These ideas are particularly interesting in the context of the recently proposed 'strong anticipation' that enables subjects to synchronize with a metronome even if the sequence is largely random. The present experimental findings may form a first step towards a better understanding of effects of (correlations in) auditory cueing on gait, which can open new opportunities for optimizing cueing protocols in the presence of neurodegenerative pathologies.

References

Boonstra, TW, He Biyu J, Daffertshofer A. Scale-free dynamics and critical phenomena in cortical activity, *Frontiers Physiol* 4 (79), doi:10.3389/fphys.2013.00079, 2013

Lim I, van Wegen E, de Goede C, Deutekom M, Nieuwboer A, Willems A, Jones D, Rochester L, Kwakkel G. Effects of external rhythmical cueing on gait in patients with Parkinson's disease: a systematic review. *Clin Rehabil* 19 (7): 695–713, 2005.

Marmelat V, Delignières D. Strong anticipation: complexity matching in interpersonal coordination. *Exp Brain Res* 222: 137-148, 2012.
Marmelat V, Torre K, Beek PJ, Daffertshofer A. Preserving healthy gait dynamics under fractal rhythmic auditory stimulation, *submitted*, 2013.
Stephen DG, Stepp N, Dixon J, Turvey MT. Strong anticipation: sensitivity to long-range correlations in synchronization behavior. *Physica A* 387: 5271–5278, 2008.

T2.1 Knowing the score: How does familiarity with a co-performer's part affect temporal coordination in musical ensembles?

Peter E. Keller[1,2], Marie Uhlig[2], & Giacomo Novembre[1,2]
[1]The MARCS Institute, University of Western Sydney, Australia
[2]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany
Email: p.keller@uws.edu.au

Ensemble performers invest in private practice and group rehearsal to achieve precise temporal coordination between individuals. Private practice involving the study of musical scores fosters familiarity with the structure of co-performers' parts, while group rehearsal additionally engenders familiarity with their playing styles. Knowledge gained through these forms of practice presumably facilitates ensemble cohesion by enhancing one's ability to predict the timing of another's actions. I will present the results of two studies that investigated the effects of privately practicing a co-performer's part on subsequent (virtual or real) ensemble coordination. In one study, pianists played the right-hand part of piano pieces in synchrony with recordings of the left-hand part, which had or had not been practiced beforehand. Transcranial Magnetic Stimulation delivered over the right primary motor cortex impaired adaptation to tempo changes in the recorded part only when it had been practiced. In the other study, pairs of pianists played repeat performances of duets for which they had previously practiced one part or both parts. Knowledge of the co-performer's part facilitated the interpersonal coordination of body sway movements, but it had detrimental effects upon keystroke synchronization. Overall, findings suggest that familiarity with a co-performer's part allows an individual to simulate its performance using his or her own motor system, and that predictions based on such simulations evolve at multiple time scales (expressive micro-timing versus phrase timing) upon which familiarity can have dissociable effects related to the distinction between musical structure and personal playing style.

T2.2 Scrutinizing subjective rhythmization: A combined ERP/oscillatory approach

Christian Obermeier[1] & Sonja A. Kotz[1,2]
[1]Max Planck Institute for Human Cognitive and Brain Sciences, Department of Neuropsychology, RG "Subcortical contributions to comprehension", Leipzig, Germany
[2] University of Manchester, School of Psychological Sciences,
Email: obermeier@cbs.mpg.de

When we listen to an isochronous sequence of identical tones (equitone sequence), we perceive some tones in as more salient than others. This phenomenon is termed subjective accentuating or rhythmization (e.g. Brochard et al., 2003, Schmidt-Kassow et al., 2011). It is assumed that listeners' attention is enhanced for odd tones as compared to even tones in a sequence, reflecting dynamic attending to the tones (see Large & Jones, 1999). Here, we used a combined ERP/time-frequency approach to specify i) how listeners subjectively establish rhythmic regularities in equitone sequences, and ii) how they use this information to predict upcoming events. We presented participants with 192 equitone sequences (13-16 tones) that either contained one or two deviants of either higher or lower intensity at odd- or even-numbered positions. Standard tones had a frequency of 440 Hz, a duration of 50 ms, and an intensity level of 70 dB. Deviants tones differed by 4 dB. The ISI was 600 ms. Participants counted the number of deviants per sequence.

Preliminary ERP analyses revealed an increased P300 for attenuated deviant tones in odd positions in contrast to deviants in even positions. The TF analyses showed reduced alpha power for deviants in odd positions compared to deviants in even positions. In contrast, alpha power was enhanced for pre-deviant tones in odd positions compared to pre-deviant tones in even positions.

Taken together the present data suggest that alpha oscillations may play an important role in subjective temporal/rhythmic chunking and prediction of upcoming auditory information.

T2.3 From Sounds to Movement and Back: How Movement Shapes Neural Representation of Beat and Meter

Sylvie Nozaradan, Isabelle Peretz, André Mouraux
Université catholique de Louvain (UCL), Belgium; International laboratory for Brain, Music and Sound Research (Brams), Université de Montréal, Canada
Email: sylvie.nozaradan@uclouvain.be

Getting entrained to musical beat and meter is an extremely common activity, shared by humans of all cultures. However, how musical rhythms are embodied in brain structures remains unclear. Using EEG to record beat and meter-related steady-state evoked potentials, we investigated how movement shapes the neural representation of meter when listening to an *ambiguous* rhythm that can induce various metric structures. In a first session, the EEG was recorded while participants listened to an ambiguous rhythm. In a second session, participants listened to the same rhythm and moved the body according to a given metric interpretation of the rhythm. Finally, in a third session, participants listened to the rhythm without moving, such as in the first session. Because the rhythm was ambiguous, we found that brain activities recorded in the first session faithfully followed the structure of sound envelope, with no selective enhancement at specific frequencies. In contrast, although participants did not move or voluntarily imagine a metric structure in the third session, the steady-state evoked potentials recorded in this session were significantly enhanced at frequencies corresponding to the metric interpretation to which they moved in the second session. These results not merely corroborate previous behavioral evidence of body movement influencing meter perception. They also take an important step forward by providing first direct evidence that movement shapes *selectively* neural representation of musical rhythms.

T2.4 How much beat do you need? An EEG study on the effects of attention on beat perception using only temporal accents.

Fleur Bouwer[1] & Henkjan Honing[1]
[1]Cognitive Science Center Amsterdam, Institute for Logic, Language and Computation, University of Amsterdam, The Netherlands
Email: f.bouwer@uva.nl

The perception of a regular beat in a musical rhythm is a very basic skill. Earlier, using naturalistic stimuli with clear acoustic accents, we have shown that the brain can detect regularity in music without attending to it (Bouwer et al., in prep; see also Ladinig et al., 2009). However, others have shown the necessity of attention for perceiving a beat in highly syncopated rhythms with only temporal accents (Chapin et al., 2010). To reconcile these differences we propose that the level of attention needed to perceive a beat depends on the complexity of a rhythm and the type of accents used. Here we test the latter prediction. We examine the relationship between attention and beat perception using strictly metrical stimuli with only temporal accents. In the current experiment participants are presented with a simple rhythm in which deviants are introduced in two different positions, either on the beat or not on the beat. Deviants occur in the form of sound increments and sound decrements. We compare the ERP response to the deviants under attended and unattended conditions. The different positions of the deviants will allow us to probe the presence of beat perception under different attentional conditions. Comparing the results from this experiment with previous work will give us insight in the role of acoustic and temporal accents in the perception of a regular beat under unattended conditions.

References:

Bouwer, F., Van Zuijen, T.L., & Honing, H. (in prep). Using event---related potentials to probe pre---attentive beat perception: The pros and cons of acoustically rich stimuli.

Chapin, H. L., Zanto, T., Jantzen, K. J., Kelso, S. J. A., Steinberg, F., & Large, E. W. (2010). Neural Responses to Complex Auditory Rhythms: The Role of Attending. *Frontiers in Psychology*, *1*, 1-18. doi:10.3389/fpsyg.2010.00224

Ladinig, O., Honing, H., Háden, G. P., & Winkler, I. (2009). Probing attentive and preattentive emergent meter in adult listeners without extensive music training. *Music Perception*, *26*(4), 377–386. doi:10.1525/mp.2009.26.4.377.

T2.5 Functional neuroanatomy of directing attention in time

Jennifer Coull
Laboratoire de Neurobiologie de la Cognition, Universite Aix-Marseille & CNCRS, Marseille, France
Email: Jennifer.coull@univ-provence.fr

Being able to predict when relevant events are likely to occur improves speed and accuracy of information processing. In a series of fMRI investigations, we have found that temporally informative cues consistently activate left intraparietal sulcus (IPS). This activation was independent of the laterality (left/right) or type (hand/eye) of motor response and was observed equally during non-motor perceptual tasks, whether temporal expectation was established endogenously via temporal cues or exogenously via visual speed or auditory rhythms. Yet temporally predictive information can also be conveyed by the unidirectional nature of time's flow. As the objective probability, and hence subjective expectancy, of event onset increases with increased waiting time ("hazard function"), activity in right prefrontal cortex increases. Taken together, these data reveal distinct neural substrates for the initial generation of a temporal expectation (left IPS) versus subsequent updating of the expectation as a function of time itself (right prefrontal).

T2.6 "Rhythms for bears to dance to": Communicative function and prosodic form in speech timing

Laurence White
Plymouth University
Email: laurence.white@plymouth.ac.uk

Speech is often described as rhythmical, but the functions that rhythm might serve in spoken language remain to be fully elucidated. Towards this end, two aspects of rhythm can be distinguished: "contrast" and "periodicity", the latter referring to the recurrence of auditory events at regular intervals. Contrast, between stronger and weaker auditory elements, is exploited in many languages for the encoding of linguistic information (e.g., stress placement in '*insight* vs *in*'*cite*). With regard to periodicity, although periodic signals can carry information through spectral/intonational variation, predictable timing is not, of itself, informative. Indeed, strict isochrony of speech units has long been discounted, in line with the principle that temporal variation is employed in speech to convey linguistic information, such as regarding lexical/phrasal structure.

Some accounts of speech timing – updating principles derived from the search for isochrony – contend that the critical units are metrically defined. In particular, segment duration is held to be influenced by the composition of metrical feet, with compensatory shortening of segments proportional to the number of syllables therein. I argue, however, that the evidence for such quasi-periodicity in temporal organisation is marginal at best. Firstly, syntactic, not metrical, constituents define the domains of durational variation shown to be exploited by listeners. Secondly, there is a perceptual asymmetry between lengthening and shortening: in line with a dynamic attending account, events that occur earlier than expected are less well attended than delayed events. Thus, speech timing serves as a structural cue for listeners through localised lengthening effects, within syntactically-defined domains.

T2.7 The role of dialect-specific vowel duration in lexical access

Rachel Smith and Tamara Rathcke
University of Glasgow
Email: Rachel.Smith@glasgow.ac.uk

Context-sensitive timing cues play a key role in many aspects of speech processing, from identifying segments to locating word and phrase boundaries. They also vary across dialects, yet the representation and processing of this variation is poorly understood. We report a word-spotting study investigating whether a dialectal difference in vowel duration affects lexical access. The vowels /i/ and /u/ are generally shorter in Glasgow English (GE) than Leeds English (LE), and exhibit different contextual conditioning. In both dialects they are short before voiceless consonants (*freak*) and long before voiced fricatives (*leave*); before voiced stops and nasals (*scheme*) LE has long duration, as typical for English, while GE has short duration according to the Scottish Vowel Length Rule. To test these differences' perceptual consequences we manipulated listener dialect, vowel duration, and phonological context. Participants were 39 GE and 39 LE speakers. Stimuli were 66 nonsense sequences containing embedded words (e.g. *flizoomip* contains *zoom* and *zoo*), spoken with segmental qualities intermediate between those of GE and LE. Duration of the critical vowels was manipulated to be *short* (appropriate for GE) or *long* (for LE) according to phonological context. LE participants were less accurate, and in certain contexts slower, than GE participants to spot embedded words with short-duration vowels; the groups did not differ on words with long-duration vowels. We discuss implications for theories of speech perception regarding the context-sensitive representation of duration, and draw connections with dynamic attending theory with respect to the arrival of information early vs. late in attentional cycles.

T2.8 Rhythmic Constraints on Read and Rapped Speech

S. Abir Anbari, Marcin Włodarczak, Petra Wagner
Faculty of Linguistics and Literary Studies
Bielefeld University
Email: {sanbari,mwlodarczak,petra.wagner}@uni-bielefeld.de

Speech rhythm in English has been described by postulating that stress beats are constrained to occur at fixed relative phases. In other words, subunits are nested within larger units non-randomly. Similar findings have been found in poetic speech (Wagner, 2012), which is often regarded as more than regular non-poetic speech. The same could be expected from rapped speech in comparison to read speech. Using the speech cycling method introduced by Cummins & Port (1998), we examine rhythmic patterns of rap and speech. In this experimental task, subjects repeat a phrase (such as *bet for a game)* in time along with a sequence of high and low beeps such that the beginning of the phrase (*bet*) is aligned with the high beep and the last word (*game*) is aligned with the low beep. The focus is on relative timing of stress beats. Two speech cycling experiments have been conducted using different conditions. In one condition, subjects read short phrases along with the stimulus. In the other condition, the same subjects were instructed to rap identical phrases. Preliminary results reproduce preferences for similar phase values to those observed by Cummins & Port (1998). Additionally, only limited evidence has been found that different constraints operate in read and rapped speech. Therefore, the original experiment by Cummins & Port (1998) is likely to have investigated what is in fact a case of rapped rather than read speech.

References

Wagner, Petra (2012). Meter specific timing and prominence in German poetry and prose. In: *Prosodies – Context, Function, Communication*. Niebuhr, O. (Ed). Berlin/New York: de Gruyter. 219 - 236.

Cummins, Fred & Port, Robert. F. (1998). Rhythmic constraints on stress timing in English. *Journal of Phonetics* 26.145-17.

T2.9 The role for auditory rhythm processing in phonological language and literacy skills.

Manon Grube, Sukhbinder Kumar, Freya E. Cooper, Cate Davison, Timothy D. Griffiths
Institute Of Neuroscience, Medical School, Newcastle University, Framlington Place, NE2 4HH.
Email: manon.grube@ncl.ac.uk

The relationship between auditory and language skills has been a matter of debate. Whilst most previous work focused on single-sound processing (Goswami et al. 2002, Rosen et al. 2009, Tallal 1980, Witton et al. 1998, Wright et al. 1997), a few recent studies used melody or rhythms (e.g. Foxton et al. 2002, Huss et al. 2011). This work investigates the processing at increasing levels of complexity, from single sounds to rhythmic sequences, to systematically test the role for regularity processing in language skill development. In a large cohort of typically developing school children (age 11; n=210), we demonstrated a significant correlation between short regular rhythmic-sequence processing and phonological language and literacy skills (Grube et al. 2012), and recently replicated this finding in a second cohort. In a subsample of individuals with dyslexic traits (n=28), the correlation with language skill differed for other tasks, but was similar for the short rhythmic sequences. In a cohort of young adults in contrast, there was a strong, significant correlation between language skills and the processing of sequences with a metrical or a quasi-regular beat, though not for those with gradual changes in tempo following a 1/f algorithm. The results demonstrate a beneficial role for beat-based rhythm processing, providing behavioural evidence in support of recent models of oscillatory brain activity at corresponding frequencies reflecting the use of the quasi-regular temporal structure of speech (Abrams et al. 2009, Giraud & Poeppel, 2012).

References:

Abrams DA et al. (2009) J Neurosci 29.
Foxton JM et al. (2003) Nat Neurosci 6.
Giraud AL & Poeppel D (2012) Nat Neurosci 15.
Goswami U et al. (2002) PNAS 99.
Grube M et al. (2012) Proc Biol Sci 279.
Huss M et al. (2011) Cortex 47.
Rosen S et al.(2009) J Speech Lang Hear Res 52.
Tallal P (1980) Brain Lang 9.
Witton C et al. (1998) Curr Biol 8.
Wright BA et al. (1997) Nature 387.

T2.10 Rhythm processing in stuttering and non-stuttering children

J. Devin McAuley, Elizabeth A. Wieland, Laura C. Dilley, & Soo-Eun Chang
Michigan State University. East Lansing, MI, USA
Email: dmcauley@msu.edu

Individuals generally show a beat-based advantage (BBA) in rhythm discrimination, namely simple metrical rhythms with a strong beat are better discriminated, remembered and reproduced than complex metrical rhythms with a weak or absent beat (Povel & Essens, 1985; Grahn & Brett, 2007). Consistent with the view that a basal ganglia-cortico-thalamic network is involved in rhythm perception, individuals with Parkinson Disease demonstrate worse rhythm discrimination and a reduced BBA compared with age-matched controls (Grahn & Brett, 2009). Developmental stuttering is another disorder that presents with difficulty initiating movements, where symptoms can be alleviated with external rhythmic pacing signals (Toyomura, Fujii, & Kuriki, 2011). The current study investigated whether children with developmental stuttering also show worse rhythm discrimination abilities compared with typically developing controls. Stuttering and non-stuttering children, aged 6-11 years, were asked to discriminate simple and complex auditory rhythms. On each trial, they heard two successive presentations of a standard rhythm and were then asked to judge whether a third (comparison) rhythm was the same or different from the standard. The task was presented in the context of a computer game, where colorful characters 'played' the tested rhythms on a drum. Stuttering children showed overall worse rhythm discrimination than non-stuttering children, but this did not appear to be associated with a reduced BBA. Findings suggest that children who stutter may have a core deficit in rhythm processing.

T2.11 Conducting: Is timing really the be all and end all?

D. Watson
Email: dan@danwatson.co.uk

Dan Watson (http://www.danwatson.co.uk/Dan_Watson/Home.html) is a professional conductor and Artistic Director of Thumb contemporary music ensemble. He describes this session as a glorified conducting lesson! But with the angle of the importance of a conductor's gesture to facilitating coherent and fluent music, which is all reliant on a strong timing foundation. Beyond that it's the conductor's job to convey interpretation and expression, which is the largest part of conducting, but none of this works without the timing foundation. Be ready to participate and learn some new skills!

T2.12 Demonstration of Birmingham Electro-Acoustic Sound Theatre (BEAST).

S. D. Wilson
Email: s.d.wilson@bham.ac.uk

Venue: Bramall School of Music (R12 Campus Map)

BEAST (Birmingham ElectroAcoustic Sound Theatre; http://www.birmingham.ac.uk/facilities/BEAST/index.aspx) is the concert sound system of the University of Birmingham's Electroacoustic Music Studios and was founded in 1982 by the Director of the Studios, Jonty Harrison, to showcase electroacoustic music produced in the Studios and around the world. The BEAST diffusion system uses multiple channels of separately amplified loudspeakers, whose differing characteristics make them appropriate for a particular position or function. The system includes arrays of tweeters (high frequency speakers which can be suspended over the audience), sub-woofers (low frequency speakers) and full-range speakers of varying characteristics and from different manufacturers. The performer is able, via a custom-built diffusion desk or a computer interface, to create a variety of sound images, and to 'sculpt' the spatial, dynamic and dramatic implications of the music in a particular performance environment in order to interpret and realise the composer's intentions. BEAST is engaged in ongoing research into new controllers and interfaces for the performance of acousmatic and electroacoustic music and can now install systems of around 100 loudspeakers.

T3.1 Rhythm, movement and the groove connection – what is it good for?

Guy Madison, Umeå University,
Email: guy.madison@psy.umu.se

Much music creates groove - the sensation of wanting to move - and music is indeed often created with that purpose. The empirical study of groove began only 15 years ago, and has rapidly spread in the music research community. Thus we now know that groove constitutes an isolable property of the inducing signal other than idiosyncratic preference, and we also know that some properties of the sound signal induce it and others do not. Here, I attempt to synthesize published and yet published data and propose a general function of groove, based on the conjecture that groove may provide information to listeners about the extent to which the sound signal promotes entrainment. In other words, groove might serve as a measure of how good the pulse is as a vehicle for entrainment.

T3.2 Slowness in music performance and perception: an analysis of timing in Feldman's "Last Pieces"

Dirk Moelants
IPEM-Dept. Of Musicology, Ghent University, Belgium
Dept. Of Musicology, University of Amsterdam, the Netherlands
Email: Dirk.Moelants@ugent.be

Perception of musical structure greatly relies on memory. Our working memory allows us to perceive musical motives and measures as a meaningful whole. Whereas most music uses this memory integration to build-up melodic, rhythmic and metric structures, some 20th century composers started to challenge this principle by stretching the time between musical events beyond the capacities of our working memory.
A good example of this is found in the work of Morton Feldman. He wanted to let the listener "listen to the sounds themselves", focusing on timbre rather than on melody and rhythm. Examples of this technique are found in his "Last Pieces", a cycle of piano pieces from 1957. In this work he gives the performer only a series of chords, without any rhythmic indication. Only an indication of the general tempo is given (slow, fast, very slow), with the note 'durations are free'. This pieces thus gives us excellent material to study how performers deal with timing, particularly how they interpret a notion like 'slow' in terms of time intervals. For this study a total of 12 interpretations of the pieces were studied, both versions published on commercial CDs and custom-made recordings. Results show important differences in interpretation between different pianists, with most performers using irregular intervals above 3 seconds, an interval that can be linked with perception theory. Finally, the relation between the structure of the chords and their performed durations will be investigated, looking at the influence of register, dissonance and density.

T3.3 Timing and synchronisation of professional musicians: A comparison between orchestral brass and string players

Dr. Timo Fischinger
Institute of Musicology and Media Science, Humboldt-Universität zu Berlin
Email: timo.fischinger@hu-berlin.de

Musicians need years of deliberate practice to learn how to adjust their timing behaviour as good as possible to the acoustic characteristics of their own musical instrument (transients and perceptual onsets) as well as to the spatial position in the orchestra respectively. In the present study, two different experimental paradigms were used to investigate the timing skills of professional musicians. The aim was to examine whether orchestral brass and string players show differences in synchronization performance under varying conditions. 20 professional musicians from a professional orchestra were asked to participate in the study. In the first experiment subjects had to synchronise by playing their own instrument (violin, viola, trumpet, trombone) with a simple metronome sequence (in each case the stimulus sound was the same as the instrument sound) in varying trials with different IOI's (= 300, 400, 500, 600, and 1000 ms). In a second experiment, subjects had to perform the classical finger tapping synchronization task to metronome sequences on a drum pad (same IOI's as in the first experiment). Overall, the results show considerable differences in synchronization performance: Subjects show a very low synchronization error in the first experiment, when they have to synchronize by playing their own instrument (brass: -1.78 ms; strings: -2.42 ms) compared to the second experiment with the classical tapping task (brass: -9.71 ms; strings: -14.25 ms). This could be due to the fact that subjects are highly trained experts on their own musical instrument, but are not used to the classical tapping condition respectively.

T3.4 It's All in the Wrist: Neural Substrates of Rhythmic Timing in Young and Older Professional Musicians and Controls

Ralf Krampe[1], Nici Wenderoth[1,2], Ann Lavrysen[1], & Stephan Swinnen[1]
[1] KU Leuven, Belgium; ETH Zuerich, Switzerland
Email: Ralf.Krampe@ppw.kuleuven.be

80 young (20--35 yrs) and older (54-67 yrs) professional musicians and age-matched novices (20 in each group) performed unimanual tapping tasks, which either required low-level timing, rhythmic sequencing, or switching between different rhythms. Data was collected during two fMRI scan sessions with (for novices) six laboratory training sessions in between. Professional musicians of both age groups outperformed novices and age-effects were pronounced in novices and in tasks requiring sequencing or cognitive control. Besides well-documented motor networks active in all groups, we found that novices heavily relied on parieto-prefrontal networks (Left IPS, Right IPL, R+L DLPFC) for sequencing and even more so for switching tasks. In contrast, expert musicians showed no (young musicians) or less activation (older musicians) of prefrontal regions or IPS in these tasks. Instead, musicians showed pronounced activation in the primary sensorimotor cortex. Acquisition and maintenance of high-level motor control apparently amounts to a gradual release from domain-general cognitive control through optimizing task-specific "lower-level" functions.

T3.5 Video-based motion capture application to characterising rhythmic activities in single or multiple human targets

Feng Zheng[1], James Brownjohn[2], Vito Racic[1]
[1] University of Sheffield Department of Civil and Structural Engineering
[2] University of Exeter College of Engineering, mathematics and Physical Sciences
Email: cip12fz@sheffield.ac.uk

The classical methods used to the analysis of rhythmic activities mostly depend on maker-based vision system or wearable movement monitors. These systems limit their application due to some problems, such as sensitivity to noise, discomfort to participants and high cost. To avoid these difficulties, in this paper, a video-based motion capture system is described, which has been developed to characterise rhythmic activities in single or multiple human targets. This system is a remote monitor and can be set up in indoor or outdoor environments. In our system, a high-speed camera is firstly used to capture the video which contains the movement of the multiple targets. Then, an on-line learning based target tracking algorithm is adopted to detect the trajectories of movement. Finally, the trajectories can be used to describe the rhythmic activities. Experiments on the various environments demonstrate that our system achieves a similar result to the classical methods, effectively avoiding aforementioned problems and with potential for a broader application.

T3.6 Synthesis of asymmetric movement trajectories by means of frequency modulation

Carl Haakon Waadeland
Department of Music, NTNU, 7491 Trondheim, Norway
Email: carl.haakon.waadeland@ntnu.no

In an experiment involving synchronisation or syncopation with an external auditory metronome Balasubramaniam, Wing, and Daffertshofer (2004) show that the nervous system produces trajectories that are asymmetric with respect to time and velocity in the out and return phases of the repeating movement cycle. On the basis of their findings, they suggest that "movement asymmetry in repetitive timing tasks helps satisfy requirements of precision and accuracy relative to a target event" (ibid., p129). Various empirical studies of drummers´ movements in the performance of different rhythms and grooves also show that the movement of the drumstick produces trajectories that are asymmetric. Results from different investigations on gestural aspects of timed rhythmic movements thus indicate that the production of asymmetric movement trajectories is a feature that seems to be a common characteristic of various performances of repetitive rhythmic patterns. The behavioural or neural origin of these asymmetrical trajectories is, however, not identified.

In the present study we outline a theoretical model that is capable of producing syntheses of characteristic features of the asymmetric movement trajectories documented in the empirical investigation of Balasubramiam et al. (ibid.), and we discuss whether this model might be appropriate in describing principles governing trajectory formation in timed rhythmic movements. The model is based on an application of frequency modulated movements and is constructed by means of a synthesis technique developed earlier by the author, which has shown to be useful in making syntheses of rhythmic expression in music (Waadeland, 2001).

References

Balasubramaniam, R., Wing, A. M., & Daffertshofer, A. (2004). Keeping with the beat: Movement trajectories contribute to movement timing. *Experimental Brain Research, 159,* 129-134.

Waadeland, C. H. (2001). "It don't mean a thing if it ain't got that swing"— simulating expressive timing by modulated movements. *Journal of New Music Research, 30,* 23–37.

T3.7 The impact of cerebellar and basal ganglia dysfunction on the accuracy and variability of motor timing

Catherine R.G. Jones[1], Daniel O. Claassen[2], Minhong Yu[3], Jeffrey R. Spies[3], Georg Dirnberger[4], Tim Malone[5], Michael Parkinson[4], Paola Giunti[4], Michael Kubovy[3], Marjan Jahanshahi[4]
[1]School of Psychology, Cardiff University, UK
[2]Department of Neurology, Vanderbilt University, Nashville, TN, USA
[3]Department of Psychology, University of Virginia, Charlottesville, VA, USA
[4]Sobell Department of Motor Neuroscience and Movement Disorders, University College London Institute of Neurology, UK
[5]Royal Devon & Exeter Hospital, UK
Email: crgjones@essex.ac.uk

Studies in motor timing have shown that the basal ganglia and cerebellum play an important role in temporal processing. Timing studies in patients with Parkinson's disease (PD) and cerebellar/ataxic disorders (CD) contrast the roles of the basal ganglia and cerebellum in motor timing. Here, we used a synchronization–continuation task to compare accuracy and variability of motor timing during repetitive tapping in patients with PD and CD as well as healthy controls. We asked participants to tap at Inter-stimulus Intervals (ISIs) of 250, 500, 1000, and 2000 ms. Using Linear Mixed Models (LMMs), we explored how ISI, Task Phase (synchronization, continuation), and Diagnosis interacted to determine the (i) the accuracy and (ii) the variability of tapping. Accuracy was defined as the relative error of a tap, and variability as the deviation of the participant's tap from group predicted relative error. For accuracy, the PD group performed "ahead" of the beat whilst the CD group lagged "behind" the beat. We speculate that the "hastening" in the PD group relates to the clinical phenomenon of motor festination. For variability, CD patients showed greater variability than the healthy controls at ISIs below 1000 ms, whereas the variability of the PD patients was not markedly different to controls. These results give insight into the differential roles of the cerebellum and basal ganglia in motor timing.

T3.8 Interpersonal motor synchrony to a musical beat as a cue for social cohesion during infancy.

Laura K. Cirelli(1)*, Kathleen M. Einarson(1), Sarah E. Lade(1), Laurel J. Trainor(1)
(1) McMaster Institute for Music and the Mind, McMaster University. Hamilton, Ontario, CANADA
Email: cirelllk@mcmaster.ca

Because of individuals' propensity to entrain movements to a musical beat, group behaviours such as dancing, singing, and playing musical instruments encourage high levels of interpersonal motor synchrony. Even young infants spontaneously produce rhythmic movements when listening to musical beats, however these movements tend to be out-of-synchrony with the beat until preschool age. Coordinated movement to music among adults is associated with increased group cohesion and social bonding between group members. Specifically, individuals who walk, sing, or tap together are subsequently more helpful, compliant or cooperative in later interactions with one another. However, whether interpersonal synchrony affects social behaviour during infancy was previously untested. In the current set of experiments, we investigated the developmental trajectory of this effect. In experiment 1, the helpfulness of 14-month-old infants following interpersonal motor synchrony was measured. We found that infants were significantly more likely to help an adult experimenter after being bounced to music in synchrony (as opposed to out-of-synchrony) with that person's movements. In experiments 2 and 3, the preferences of 10- and 12-month-olds were measured for a nonhuman (puppet) agent that either bounced to music in- or out-of-synchrony with how the infant was bounced. These younger infants do not seem to form preferences for interpersonally synchronous nonhuman agents. This suggests that the cue of interpersonal synchrony is only salient after the first year of life, or that human agency is a fundamental condition of this cue. Experiment 4 (ongoing) will further investigate the importance of human agency with 10- to 12-month-old infants.

T3.9 Moving to the beat: Analysing motion responses to different pulse shapes

Anne Danielsen, Mari Romarheim Haugen, and Alexander Refsum Jensenius
Department of Musicology, University of Oslo, Norway
Email: anne.danielsen@imv.uio.no

Pulse is a fundamental reference for the production and perception of groove-based rhythm. In this paper, we focus on listeners' motion responses to changes in the *shape* of the pulse. As our example we use the tune Left&Right by D'Angelo (*Voodoo* 2000). Part one of this tune (intro) implies one accurate and point-like location of the pulse, while in part two (main groove) different rhythmic layers suggest two different pulse locations 80ms apart. First, we theorize the response to this change in beat shape, using theories of entrainment and dynamic attending as point of departure. Then we report from a motion capture experiment aimed at examining listeners' responses. Our hypothesis was that motion would change from part one to part two as a consequence of the altered shape of the pulse. 20 music students were recruited.

While standing on the floor, they were instructed to naturally move a stick in their hand to the pulse of the music. The results for the quantity of motion showed that the subjects on average moved more to part two than to part one by a factor of 1.4 (SD=0.4). Plots of the responses show that for a majority of subjects there is a clear change in motion, both qualitatively and quantitatively, from part one to two. Given the coupling between action and perception in musical rhythm, this difference in motion response can reflect a difference in perceptual response caused by the micro-rhythmic alterations in the groove.

T3.10 The spatial-tapping task to reveal the coexistence of event-based and emergent timing for the control of rhythmic sequences.

Authors: Mariama Dione, Laurent Ott, Yvonne Delevoye-Turrell
Affiliation: URECA, UPRES EA1059, Université Lille3
Research themes: Behavioural Neuroscience, Cognitive Psychology, Motor control
Email: mariama.dione@univ-lille3.fr

The control of rhythmic motor sequences may involve two distinct timing processes, i.e. event-based and emergent timing. Event-based timing refers to the mode of action control in which the task goal is to maintain timing accuracy (Wing & Kristofferson, 1973a, 1973b), while in emergent processes, the timing emerges from the dynamics of control of the spatial trajectory (Robertson et al., 1999; Turvey, 1977). These timing modes have been revealed through finger tapping and circle drawing tasks, respectively (Zelaznik, Spencer, & Doffin, 2000; Zelaznik, Spencer, & Ivry, 2002). In the present study, we used a hybrid-pointing task in order to assess whether the two modes could co-exist within a unique movement, as suggested by Repp & Steinman (2010).
Sixty-eight participants performed a spatial-tapping task in which they were instructed to produce discrete tapping actions around a circular trajectory, across nine distinct tempi (1100 to 300 ms of inter-onset-interval). Autocorrelation functions (AC) of the inter-response-intervals were calculated up to ten lags to reveal series dependencies. Significant negative AC-1 were revealed at tempi ≥ 700 ms, suggesting that the timing was event-based at these tempi, and significant positive AC-6 were revealed at tempi ≤ 500 ms, suggesting that the timing was emergent at these slow tempi. Furthermore, an analysis of the spatial errors indicated that the timing errors were the smallest between 1100 to 900 ms of IOI, intermediate between 800 to 600 ms of IOI, and the largest between 500 to 300 ms of IOI, pattern that follows the index of difficulty of the task. Finally, between 600 to 300 ms of IOI the endpoint distributions were significantly more oriented in function of the tangent to the circle, with the emergence of an anchor point in the spatial trajectory, suggesting that the task goal at faster tempi was to smooth the tapping actions within a global circular pattern rather than maintaining timing accuracy per se (see Roerdink, Ophoff, Peper, & Beek, 2008 for descriptions of the anchoring phenomenon).

Overall, our results suggest that for sequential motor control, two different timing modes can be used in function of task constraints. Autocorrelation analyses suggest that event coding is used at slower tempi (≥ 900 ms), and that an emergent timing mode is used at faster tempi (≤ 500 ms). For intermediate tempi, the temporal pressure was higher and the control was maintained event-based between 800 to 700 ms of IOI, with however a significant decrease in subjects' performances. A combination of modes was revealed around 600 ms of IOI. Hence, we conclude that our results argue in favour of the coexistence of the two timing within the same motor sequence as a balance, with one mode taking over when timing is the priority (event-coding at slow tempi) and the other being dominant when the spatial aspect of the task is set as the priority (emergent-coding at fast tempi).

References

Repp, B., & Steinman, S. (2010). Simultaneous event-based and emergent timing: synchronization, continuation, and phase correction. *Journal of Motor Behavior*, *42*(2), 111–126.

Robertson, S., Zelaznik, H., Lantero, D., Bojczyk, K., Spencer, R., Doffin, J., & Schneidt, T. (1999). Correlations for timing consistency among tapping and drawing tasks: evidence against a single timing process for motor control. *Journal of experimental psychology. Human perception and performance*, *25*(5), 1316–1330.

Roerdink, M., Ophoff, E., Peper, C., & Beek, P. (2008). Visual and musculoskeletal underpinnings of anchoring in rhythmic visuo-motor tracking. *Experimental Brain Research.*, *184*(2), 143–156.

Turvey, M. (1977). Preliminaries to a theory of action with reference to vision. *Perceiving, acting and knowing*, 211–265.

Wing, A., & Kristofferson, A. (1973a). Response delays and the timing of discrete motor responses. *Perception & Psychophysics*, *14*(1), 5–12.

Wing, A., & Kristofferson, A. (1973b). The timing of interresponse intervals. *Attention, Perception, & Psychophysics*, *13*(3), 455–460.

Zelaznik, H., Spencer, R., & Doffin, J. (2000). Temporal precision in tapping and circle drawing movements at preferred rates is not correlated: further evidence against timing as a general-purpose ability. *Journal of motor behavior*, *32*(2), 193–199.

Zelaznik, H., Spencer, R., & Ivry, R. (2002). Dissociation of explicit and implicit timing in repetitive tapping and drawing movements. *Journal of experimental psychology. Human perception and performance*, *28*(3), 575–588.

T3.11 Enculturation, Learning and Plasticity in the Development of Rhythm Perception & Entrainment

Laurel Trainor
Department of Psychology, Neuroscience & Behaviour, McMaster University
McMaster Institute for Music and the Mind
Rotman Research Institute, Baycrest Hospital, Toronto, Canada
Email: ljt@mcmaster.ca

Long before they can entrain their movements to a musical beat, young infants have some ability to discriminate rhythmic patterns, distinguish languages on the basis of prosodic cues, and perceive metrical structure. At the same time, infants' perception becomes tuned over the first year after birth to best process metrical structures in the language and music systems to which they are exposed. Despite motoric immaturity, we have demonstrated that the auditory and motor systems are connected in infancy. Specifically, we found that bouncing an infant on either every second or every third beat of a metrically ambiguous rhythm pattern leads them to perceive that ambiguous rhythm as in either duple or triple meter, respectively. Furthermore, there are social consequences for such movement entrainment early in development. At 14 months of age, we found that infants bounced to music in sync with an experimenter are more likely to subsequently help that experimenter compared to infants bounced out of sync with an experimenter. At the same time, it takes many years for children to master entraining their own movement to an auditory beat. And enriched auditory-motor experience leads to enhanced beat perception. We found that disk jockeys (DJs) and percussionist show a superior ability to maintain a beat in their head compared to non-musicians, and one week of "DJ school" in non-DJs enhances this ability. Furthermore, allowing participants to move while making their judgements enhances performance in all groups. In recent MEG and EEG studies, we are investigating the brain basis for auditory motor interactions in rhythm processing, and have shown that the presentation of an auditory beat in the absence of movement leads to fluctuation in induced beta band (~20 Hz) oscillatory activity in both auditory and motor regions that follows the tempo of the beat and predicts expected beat onsets. Finally, in a series of studies we are investigating perceptual and physiological constraints on processing pitch and timing in polyphonic musical contexts where there are several melody lines or "voices" occurring the same time.

These studies reveal a “high voice superiority effect” for pitch processing that arises at the level of the cochlea and explains why the melody is most often placed in the highest voice. Furthermore, this effect is present in very young infants, suggesting an innate origin. Most recently, we have demonstrated a “low voice superiority effect” for time processing that can explain why bass-range instrument are most likely to carry the rhythm in music.

Poster Presentations

P1.1 Using EEG with children and adults to measure oscillatory activity in response to isochronous auditory sequences.

Laura Cirelli*, Ayda Ghahremani, Fiona Manning, Christina Spinelli, Celine Marie, Dan Bosnyak, Takako Fujioka, Laurel Trainor
McMaster Institute for Music and the Mind, McMaster University. Hamilton, Ontario, CANADA
Email: cirelllk@mcmaster.ca

Recent research using magnetoencephalography (MEG) on auditory-motor interactions in the brain indicates that oscillatory networks become entrained to the tempo of auditory isochronous sequences. For example, the amplitude of induced oscillatory activity in the auditory cortex beta band (15-25 Hz) was shown to decrease after each beat and rebound prior to the expected onset time of the next beat across different tempos. The current study investigated 1) whether similar results in the auditory cortex could be found using electroencephalography (EEG), and 2) how this activity changes with age. Adults and 7.5-year-old children passively listened to isochronous tone sequences at three different tempos (390 ms, 585 ms, 780 ms) while their EEG was recorded. In adults, evoked power in beta, but not alpha or gamma, depended on the tempo. Furthermore, beta power was higher for slower tempos, suggesting it was not simply driven by neural recovery periods. Induced power in the auditory cortex beta band appeared to decrease after each tone and then rebound immediately prior to the onset of the subsequent tone, supporting the MEG results. This pattern was similar for both children and adults when IOIs were fast (390 ms or 585 ms). However, in the slowest tempo condition (780 ms), children's induced beta power was less indicative of clear oscillatory entrainment than adults'.

P1.2 How do non-auditory senses contribute to rhythm perception?

Clare Cullen
Queen Mary University, London
Email: clare.cullen@eecs.qmul.ac.uk

Most research in rhythm perception has focussed on auditory perception without addressing the effects of other modalities. Several studies have examined the links between auditory and visual rhythm perception (Rosenbusch & Gardner, 1986; Jancke et. al, 2000; McAuley & Henry, 2010; Grahn, 2012), finding that participants are generally weaker when responding to visual rhythms. However, very little research has been carried out on how haptic feedback, and visual feedback which incorporates motion, influence rhythm perception.
The poster will outline the results of a forthcoming experiment which measures participants' ability to discriminate rhythms via auditory, visual and haptic modalities. The experiment is based on two previous studies, Can we see the beat? (Grahn, 2012) and Rhythm perception through different modalities (Kosonen and Raisamo, 2006), both of which reveal that there is a significant case for investigating non-auditory modalities and rhythm perception, especially in terms of user preference.
The results of this initial study will influence further research on the possibilities of using multimodal feedback to improve basic rhythm perception. The key aims of this wider research focus are to investigate how non-auditory senses contribute to rhythm perception, to examine the causes and effects of individual variation in rhythm abilities through understanding its correlates with other aspects of the individual (heart rate, speech, mobility, cultural experience), and to explore whether, or how these abilities can be improved through considering multiple modalities.

P1.3 A dual-task approach to study temporal preparation induced by auditory and visual rhythms

Diana Cutanda, Ángel Correa, & Daniel Sanabria
Departamento de Psicología Experimental, Universidad de Granada, Spain
Email: diana.cutanda@gmail.com

The aim of this study is to investigate whether participants can develop temporal preparation driven by auditory or visual isochronous rhythms when concurrently performing a working memory task within the same modality. Participants respond either to an auditory (Experiment 1) or to a visual target (Experiment 2) presented after a regular or an irregular sequence of auditory or visual stimuli, respectively. This task is performed concurrently with a working memory task. We expect participants to respond faster after regular compared to irregular rhythms and that this effect will not be affected by the performance of the secondary working memory task. In addition, we expect visual rhythms to produce smaller effects of temporal preparation than auditory rhythms when matched in perceptual features (e.g., duration of the stimuli forming the rhythm). These results would suggest an auditory advantage for temporal preparation driven by rhythms.

P1.4 Impaired Numerical Ability Affects Supra-Second Time Perception

Sharon Gilaie-Dotan, Geraint Rees, Brian Butterworth, and Marinella Cappelletti
UCL Institute of Cognitive Neuroscience, 17 Queen Square, London, WC1N 3AR, UK
Email: s.gilaie-dotan@ucl.ac.uk

It has been suggested that numerical and time processing rely on common magnitude mechanisms, yet for time this commonality has mainly been investigated in the sub-seconds rather than the supra-seconds time range. However, supra-sec and not sub-sec timing involves operations such as counting, subtracting and adding which are closer to the numerical domain. Here we examined whether number processing can influence timing in the supra-sec time range. Specifically, we tested supra-sec timing in adult individuals with a developmental impairment in numerical processing (dyscalculia), reasoning that supra-sec timing impairment co-occurring with dyscalculia may be indicative of joint mechanisms of time and number processing. Temporal estimation of supra-second durations (12s), non-temporal difficulty-matched control task, as well as additional mathematical abilities were measured in dyscalculics and in age-matched controls. Dyscalculics were significantly impaired in supra-sec (12s) duration estimation but not in the control task. Furthermore, supra-sec temporal ability positively correlated with mathematical proficiency. These results suggest that numerical processing and supra-sec temporal processing share common mechanisms. We assume that this is not due to an impairment of a generic magnitude mechanism or in the pacemaker of the internal clock function. Instead, we hypothesize that counting, which seems inseparable from supra-sec timing and is also innately impaired in dyscalculia, underlies and adversely affects their supra-sec time perception performance.

P1.5 Temporal preparation contributes to the overestimation of duration of 'oddball' events

Fromboluti, E.K*, Katherine Jones, J. Devin McAuley
Michigan State University. East Lansing, MI, USA
Email: kimelis1@msu.edu

Durations of deviant ("oddball") stimuli embedded within series of identical ("standard") stimuli tend to be overestimated. Past studies have attributed this oddball effect to the unexpected nature of the oddball. However, in the oddball paradigm, an oddball stimulus typically occurs on every trial in one of several potential serial positions that vary from trial to trial. Thus, there is an expectation for the oddball to occur on each trial and individuals can prepare for the oddball to occur in later serial positions. We considered the contribution of temporal preparation to the oddball effect by (1) comparing perceived duration of auditory oddballs occurring after filled or unfilled variable foreperiods (FPs), (2) varying likelihood of oddball occurrence on each trial, and (3) investigating trial-to-trial effects. Participants either heard 9-tone sequences (filled FP condition) where the oddball occurred in the 5th – 8th serial position or 2-tone sequences (unfilled FP condition), which were matched to the 9-tone sequences, but all of the tones except the first standard and the oddball were removed. Participants either detected the oddball as quickly as possible (Experiment 1) or judged oddball duration relative to standard duration (Experiment 2). Results revealed faster detection and longer perceived duration of oddballs at longer FPs, effects that both weakened as expected with decreasing likelihood of oddball occurrence on a given trial. Results support the view that temporal preparation contributes to systematic distortions in the perceived duration of deviant oddball stimuli by enabling faster initiation of the timing of the oddball.

P1.6 Stretching Time: The Effects of a Pharmaceutical sleep aid on Time Perception

Kelly M. Rowe1, Elizabeth A. McDevitt1, Nicola Cellini2, Katherine A. Duggan1 Sara C. Mednick1
1Department of Psychology, University of California, Riverside, CA;
2Department of General Psychology, University of Padua, Padua, Italy
Email: kellymorganrowe@gmail.com

We examined the effect of a sleep aid (zolpidem, i.e., ambien) on perceived sleep-time. We correlated objective measures of sleep (i.e., wake after sleep onset (WASO), sleep latency and total sleep-time (TST)) with self-reported estimations of sleep time (subjective sleep-time (SST)). We asked: 1) What is the effect of zolpidem on SST? And 2) Which measures of sleep are associated with SST estimations? In a within-subjects design, 19 (11F) healthy, young adults, received zolpidem (5mg or 10mg) or placebo, followed by a 90-minute, polysomnographically recorded nap. SST was reported on a post-nap questionnaire. We evaluated group differences for SST and the difference between SST and TST (Tdiff), where a positive score indicated an overestimation of sleep-time. We analyzed drug effects using a repeated-measures ANOVA on the following variables (all measured in minutes): SST, Tdiff, WASO, sleep latency, and TST. We also correlated SST and the aforementioned objective sleep measurements. SST was longer in the zolpidem compared to placebo conditions (5mg: p=.03; 10m: p=.005), indicating subjects felt they had slept longer in both zolpidem conditions compared to placebo. This was also reflected in overestimations of TST in Tdiff compared with the placebo (5mg p=.100 and 10mg p=.003). Tdiff was negatively correlated with minutes of wake after sleep onset (WASO) within each condition, suggesting that zolpidem may increase subjective sleep-time by decreasing minutes of WASO. No significant differences in TST or sleep latency were observed. Collectively these results suggest, zolpidem increases perceived (not objective) sleep-time by altering the characteristics of sleep.

P1.7 Prediction of event valence by time of occurrence: A case of anticipative emotion regulation?

Roland Thomaschke & Gesine Dreisbach
University of Regensburg
Email: Roland.Thomaschke@psychologie.uni-regensburg.de

Human cognition and behaviour are to a large degree guided by affective information, and affective aspects are prevalent in our everyday environment. Fast and efficient processing of these affective aspects is essential for successful communication, goal-directed behaviour and social interaction. We investigated whether valence processing can be assisted by temporally specific expectancy. Emotional aspects of situations often accord to characteristic temporal patterns. Sales pitches, for example, often begin with a rather negatively framed offer; follow by a positively framed one. Does the temporal predictability of such patterns assist one in cognitively processing the emotional framing? We investigated whether temporal predictability of valence assists linguistic processing on the single word level. In a response time experiment we presented words with negative or positive valence after a long or a short warning interval. Participants had to categorize the word's gender. Interval duration and valence were both task-irrelevant but were correlated with each other (valance was predictable from interval duration with a probability of .8). Response times were faster for frequent combinations of valence and interval than for infrequent. We conclude that temporal valence predictability assists valence processing. Valence being task irrelevant excludes an interpretation in terms of temporally specific response preparations.

P1.8 Rhythm Pattern Theory and a Binary Rhythm Pattern Indexing System

David Aldridge, independent publisher/author/lecturer
Email: davidaldridgedrums@yahoo.com

I'm the author of *The Elements of Rhythm Vols. I & II*, a two volume series that presents a binary approach to generating the fundamental building block rhythm patterns from which all larger, more complex patterns originate. One application of Volume I is as a rhythm pattern resource, useable by virtually any music researcher to identify and categorize the fundamental patterns and exchange information across multi---disciplinary platforms employing an indexing system similar to the Dewey Decimal system. Using the basic formula 2n, I calculate the possible number of silence/sound combinations for up to eight division levels of a single beat (e.g., 21, 22, 23, 24, 25, 26, 27, 28). I then systematically combine 0's and 1's (representing silence and sound, respectively) in a two---column matrix to generate the theoretical possibilities. Lastly, I replace the 0's and 1's with rest/note values of equal duration to generate the music notation possibilities. These patterns are then written out on single music staffs for practice and performance. The Binary Rhythm Pattern Indexing System I created categorizes the evolution of the patterns in terms of beat division level and sequence of occurrence. For example, patterns created at the second division level of the beat would be numbered 2.1, 2.2, 2.3, 2.4, and can be subsequently identified in printed music. Examples maybe found at www.theElementsofRhythm.

P1.9 Statistical table for the Wing & Kristofferson model

Jacques LARUE
Université d'Orléans
Email: jacques.larue@univ-orleans.fr

The seminal work of Wing & Kristofferson (1973) made possible the evaluation of both central and peripheral processes in isochronous tapping. Violations of the assumptions of the model are often reported. Surprisingly, considering the stochastic nature of the postulated mechanisms, there is no guideline regarding the probability of observing or not the expected behaviors. In other words, in a given experiment, how many times the model's assumptions could be met through random behaviors? – how much "valid trials" have to be observed to be considered as statistically different from those produced by chance only? This work simulated sets of random normally distributed intertap intervals while varying the number of subjects and taps for each set. A subject is declared valid when all validity conditions are met (negative lag1 autocorrelation; not less than -.5; near zero lag2 autocorrelation). The total number of "valid subjects" in each set is computed. The simulation is repeated a thousand times to produce the distribution of total numbers of valid subjects. Results show that a large number of subjects could meet the validity criteria of the model simply by chance. Providing longer series of taps protects against that tendency. The 5% significance threshold in the number of subjects showing valid behaviors must equal or exceed as much as 70% of the subjects involved in an experiment, but not less than 25%. A table is provided to check for significance threshold of valid subjects/trials.

P1.10 Interactions of force and time control investigated through state transitions

Chua, W. L., Maij, F. & Wing, A. M.
Email: w.chua.1@bham.ac.uk

In producing repetitive rhythmic movements such as finger tapping or pulse production, there is ambiguity regarding how independently force and timing are controlled at the central level. Tapping studies involving Parkinson and cerebellar patients report increased variability in one parameter but the preservation of the other, indicating independent control. However, when producing a force accent within a sequence of responses, simultaneous changes in timing suggest coupled control. We hypothesized that force and timing control behave independently but will exhibit parallel transient changes during execution of an anticipated state transition, and subsequently revert to independence. A transition is a change in state, where stress is introduced in the system, possibly loading cognitive resources and subsequently affecting control behaviour.

Twelve participants were trained on a pulse production task (tapping without lifting finger off the surface) at 'Fast' (600ms) and 'Slow' (1000ms) speeds as well as 'Hard' (2.5N) and 'Soft' (1.5N) forces. They then performed either an up-switch or a down-switch on the manipulated parameter (Time manipulation: fast to slow and slow to fast; Force manipulation: hard to soft and soft to hard). Observations on the non-manipulated parameter show transient changes occurring about the point of transition before returning to a stable state, suggesting coupling. However, differences in variability patterns of time and force during stable state indicate distinct control pathways. We conclude that force and timing control is generally independent but can be dependent during preparation and execution of an anticipated state transition, perhaps when cognitive resources are consciously engaged.

P1.11 Synchronization and continuation during a dance act

Helena Sgouramani1, Chris Muller[2], Leon van Noorden[2], Marc Leman[2], & Argiro Vatakis[1,3]
[1] Postgraduate Program Basic and Applied Cognitive Science, Department of Philosophy and History of Science, University of Athens, Greece
[2] Institute for Psychoacoustics and Electronic Music (IPEM), Ghent University, Belgium
[3] Cognitive Systems Research Institute (CSRI), Athens, Greece
Email: elenisgou@live.com

Timekeeping involves planning and precise movement control and is important for a variety of rhythmic activities. The issue has been extensively examined in finger tapping tasks using a synchronization-continuation paradigm [1]. The modality (e.g., [2]) and the physical properties of the external pacer (e.g., [3-4]) seem to modulate the performance, thus the nature of the pacer should be further examined. Moreover, acquired knowledge has been proposed as an influential factor in studies comparing experts with naïve participants (e.g., [5-6]). Additionally, the actual movement involved modulates synchronization patterns; therefore the characteristics of the movement itself may be important to such tasks (e.g., [7]).

Our study aimed to explore, for the first time, synchronization-continuation paradigm in an ecologically valid and embodied set-up. We used whole-body audio-visual stimuli in normal, blurred, and abstract conditions, in order to clarify the role of the metronome’s attributes in performance. A simple dance step as required movement enabled us to examine the possible differences from the usual finger-tapping tasks, and the measurement of the movement data via a motion capture system gave us the opportunity to have accuracy at a millisecond level. Additionally, the groups of participants divided into dancers versus naives let us look into possible differences due to experience and many years of training. We are currently analyzing the data, looking if the nature of the pacer influences performance with the normal condition facilitating synchronization compared to blurred and abstract one and we expect dancers to show performance superiority in comparison to naïve participants.

References

[1] Repp, B. (2005). Sensorimotor synchronization: A review of the tapping literature. *Psychonomic Bulletin & Review,* **12(6),** 969-992.

[2] Elliott, M. T., Wing, A.M., & Welchman, A.E. (2010). Multisensory cues improve sensorimotor synchronization. *European Journal of Neuroscience*, **31**, 1828-1835.

[3] Hove, M. J., Spivey, M., & Krumhansl, C. L. (2010). Compatibility of motion facilitates visuomotor synchronization. *Journal of Experimental Psychology: Human Perception and Performance,* **36(6)**, 1525-1534.

[4] Ruspantini, I., D'Ausilio, a., Maki, H., & Ilmoniemi, R. J. (2011). Some considerations about the biological appearance of pacing stimuli in visuomotor finger-tapping tasks. *Cognitive Processes,* **12**, 215-218.

[5] Krause, V., Pollok, B., & Schnitzler, A. (2010). Perception in action: The impact of sensory information on sensorimotor synchronization in musicians and non-musicians. *Acta Psychologica,* **133**, 28-37.

[6] Miura, A., Kudo, K., Ohtsuki, T., & Kanehisa, H. (2011). Coordination modes in sensorimotor synchronization of whole-body movement: A study of street dancers and non-dancers*. Human Movement Science,* **30,** 1260–1271.

[7] Rodger, M. W. M., & Craig, C. M. (2011). Timing movements to interval durations specified by discrete or continuous sounds*. Experimental Brain Research,* **214,** 393-402.

P1.12 Seeing the bounce, hearing the beat: Effects of periodic visual biological motion on the perception of auditory rhythms

Yi-Huang Su
Technical University Munich
Email: yihuang.su@tum.de

Although audition typically dominates the rhythm domain, recent research has demonstrated improved visual rhythm perception and synchronization using motion stimuli (e.g. a bouncing ball). Thus far, it is not clear whether, and to what extent, an observed human biological motion can induce a beat. The present study examined whether an observed periodic biological movement can induce a beat that will reinforce or interfere with the underlying beat of an auditory rhythm. In two experiments, participants listened to three repetitions of a weakly metrical rhythm either by itself, or preceded and accompanied by 1) an in-phase auditory beat (downbeat and upbeat), 2) an in-phase bouncing human point-light figure, 3) in-phase auditory beat and visual movement, and 4) auditory beat with the visual movement in anti-phase, after which they reproduced the rhythm once (reproduction task) or indicated the presence of any change in the rhythm (change detection task), respectively. Rhythm reproduction appeared more accurate with an explicit beat in the auditory modality. Regarding change detection, when accompanied by a phase-congruent bimodal beat, sensitivity to a shifted tone in the rhythm was higher at the downbeat than at the upbeat position. This pattern was reversed when the visual movement was in anti-phase to the auditory beat. Further analyses revealed that, in the case of bimodal beats, sensitivity was mainly modulated by the phase of the visual movement. These results suggest the potential of periodic visual biological motions as beat-inducing stimuli, which may be based on the internal sensorimotor coupling in rhythm perception.

P1.13 Behavioural Asynchrony Taints the Interaction Context

J. J. Honisch[1], K. A. Quinn[1,2], & J. T. Cacioppo[3]
[1]School of Psychology, University of Birmingham, UK
[2]Department of Psychology, DePaul University, USA
[3]Department of Psychology, University of Chicago, USA
Email: J.J.Honisch@bham.ac.uk

Behavioural synchrony, relative to asynchrony, appears to promote relationship-salutary outcomes (e.g., liking, cooperation). We explored the possibility that these effects are driven by the deleterious effects of asynchrony rather than the beneficial effects of synchrony. Based on the assumption that individuals tend to expect social interactions to be smooth, we reasoned that synchrony might actually represent a psychological baseline for social interaction expectancies and that the experience of asynchrony might taint the interaction experience. Participants were exposed repeatedly to valence-neutral words and non-words on a computer while simultaneously finger-tapping in time with auditory cues presented via headphones. In the synchrony and asynchrony conditions, two participants performed the task together and were exposed to either synchronous or asynchronous auditory cues; in the control condition, participants took turns completing the task. Although participants' post-task ratings of the word stimuli did not differ as a function of condition (presumably because of the words' pre-existing associations[1]), their ratings of the previously meaningless non-word stimuli supported our reasoning: Participants in the synchrony and control conditions rated the non-word stimuli as valence-neutral, but participants in the asynchrony condition rated the same stimuli as negatively valenced (and as more negative than participants in the other conditions).

P1.14 Can dancers suppress the haptically mediated inter-personal synchrony during voluntary periodic sway?

George Sofianidis[a], Vassilia Hatzitaki[a*], Mark Elliott[b], Alan Wing[b]
[a]Laboratory of Motor Control and Learning, Department of Physical Education and Sport Sciences, Aristotle University of Thessaloniki, Thessaloniki, Greece
[b]Behavioural Brain Sciences Centre, School of Psychology, University of Birmingham, Birmingham, United Kingdom
Email: giosof01@gmail.com

Interpersonal synchrony emerges spontaneously between individuals performing together rhythmic activities while communicating by means of different sensory feedback [1-3]. In this study we asked whether experts of traditional dance can suppress the spontaneous haptically mediated inter-personal synchrony. Sixty participants formed three types of couples: 10 expert couples (20 expert dancers), 10 novice couples (no dancers) and 10 mixed couples (one expert dancer and one no dancer). Partners swayed rhythmically for 60s at different pacing frequencies (0.25Hz - 0.35Hz) at three experimental conditions a) with no contact between them, b) with light fingertip touch established in the 2nd trial segment (30s) and c) with light fingertip touch released in the 2nd trial segment (30s). Spectral analysis of the Centre of Pressure signals in the sagittal plane revealed that light touch increased the deviation of the dominant from the target sway frequency, decreased the proportion of the signal's power at the target frequency and increased the coherence between the partner's sway signals. These effects were specific to the mixed group partners whereas touch interference was weaker in the novices and absent in experts. These results suggest that practice with traditional dance can modulate the spontaneous tendency toward haptically mediated interpersonal synchrony.

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References

1. Johannsen, L., A. Guzman-Garcia, and A.M. Wing, *Interpersonal Light Touch Assists Balance in the Elderly.* Journal of Motor Behavior, 2009. **41**(5): p. 397-399.
2. Schmidt, R.C. and B. O'Brien, *Evaluating the dynamics of unintended interpersonal coordination.* Ecological Psychology, 1997. **9**(3): p. 189-206.
3. Shockley, K., M.V. Santana, and C.A. Fowler, *Mutual interpersonal postural constraints are involved in cooperative conversation.* Journal of Experimental Psychology-Human Perception and Performance, 2003. **29**(2): p. 326-332.

P2.1 Stages of Beat Perception and the Influence of Incongruity: An fMRI Study

Daniel J. Cameron & Jessica A. Grahn
Brain and Mind Institute, Department of Psychology, University of Western Ontario
Email: dcamer25@uwo.ca

Humans sense a periodic beat in metric, non-isochronous, auditory sequences such as musical rhythms. Beat perception occurs in stages: orienting attention to absolute intervals in the rhythm to extract the metrical beat (beat finding), anticipating the ongoing beat (beat continuation), and adapting to changing rhythm (beat switching). In music, multiple rhythms are often heard concurrently, with one perceived beat rate, even if beat rates of individual rhythms are different. This incongruence can manifest as polyrhythm or metric ambiguity. We used fMRI to investigate brain activation across stages of beat perception in congruent and incongruent rhythmic sequences. Participants heard auditory rhythms composed of two strongly metric (highly beat-inducing) tone sequences. The two sequences in each trial had either congruent or incongruent metrical beat rates, and were presented in either a simultaneous or staggered fashion. For staggered trials, one sequence began, the second faded in, and after playing simultaneously, the first dropped out. This induced a change in the perceived beat, allowing us to investigate beat switching. Results indicated that orienting attention to intervals (beat finding) produced greater parietal and cerebellar activations compared to ongoing prediction (beat continuation). Continuation produced greater left premotor activations compared to finding. Adapting to a changing rhythmic stimulus (beat switching) produced greater anterior insular activations compared to finding. For incongruent compared to congruent trials, we found greater activation in anterior insula, superior temporal gyrus and inferior frontal gyri. These results suggest that distinct neural substrates underlie the stages of beat perception and are influenced by incongruence.

P2.2 Auditory-motor synchronization amplifies the effects of periodicity on auditory deviance processing: a P300 study

Maren Schmidt-Kassow, Linda Heinemann, Cornelius Abel, Jochen Kaiser
Affiliation: Institute of Medical Psychology, Goethe University, Frankfurt am Main, Germany
Email: schmidt-kassow@med.uni-frankfurt.de

Temporal predictability of auditory events induces larger P300 amplitudes and shorter latencies compared to variable onset asynchronies. This suggests that periodic stimuli lead to a more efficient allocation of attentional resources. Simultaneous synchronized motor activity should facilitate the precise temporal encoding of acoustic sequences.

We used an auditory oddball paradigm to assess whether auditory-motor interaction may amplify the effect of temporal regularity on attention allocation. Participants listened to periodic and aperiodic continuous tone sequences and were asked to silently count rare deviant tones that differed in sound frequency from the standard tones. They did so a) during a physically inactive control condition and b) while pedalling on a cycling ergometer. In the cycling condition, we monitored the individual variability of auditory-motor synchronization as a possible further determinant of successful attention allocation and stimulus processing. We hypothesized (1) decreased P300 latency, increased P300 amplitude and a better performance in response to periodic compared with aperiodic stimuli. This effect should be modulated by auditory-motor synchronization resulting stronger timing effects for the auditory-motor condition. (2) P300 latency and P300 amplitude should vary as a function of motor variability. Cycling variability was expected to correlate positively with P300 latency and negatively with P300 amplitude. We found that simultaneous cycling compared to a physically passive situation amplified the predictability effect on the P300 component. Furthermore, the temporal variability of cycling behavior correlated with both P300 latency and amplitude. These findings indicate that auditory-motor synchronization enhances the attentional processing of periodical auditory stimuli.

P2.3 Motor timing in dyslexia: Evaluating findings to date to reappraise the neural basis of timing impairments

Emma E. Birkett
Cognitive & Affective Neurosciences Group, School of Life & Health Sciences, Aston University, Birmingham, B4 7ET, UK
Email: birketee@aston.ac.uk

Studies conducted over the last 35 years have indicated that deficits in motor timing are common in children with dyslexia. A number of hypotheses have been proposed in order to link temporal processing deficits on isochronous and non-isochronous rhythmic tasks to the core symptoms of dyslexia such as impaired phonological processing. However, the location of the timing difficulty in these children within the neural network responsible for temporal processing remains unclear. Re-examining the characteristics of motor timing in children with dyslexia will help to determine the primary loci of the deficit. Previous research and recent findings from our own lab demonstrating the different features of motor timing in children with dyslexia will be reviewed (features such as increased performance variability, increased tap-tone asynchrony and slower responses to phase and period shifts, when performing to isochronous stimuli). This research will be discussed alongside evidence for the contribution of different parts of the neural timing system to timing behaviour. The conclusion will focus on what this profile of difficulties tells us about the likely location of the motor timing impairment within the temporal processing system in children with reading difficulties. Examples of atypical developmental can help to shed light on the functional mechanisms through which timing ability develops within typically developing children.

P2.4 Prosodic Structure and Cycling in Greek and Korean

Younah Chung,[1] Amanda Ritchart,[1] Amalia Arvaniti[1,2]
[1]*University of California San Diego* [2]*University of Kent*
Email: a.arvaniti@kent.ac.uk

Three experiments were conducted in Greek and Korean using cycling in which speakers produce short phrases in time with a metronome by rhythmically structuring their utterances to keep stressed syllables in stable phase within each cycle, a process resistant to speaking rate changes or the number of unstressed syllables between stresses. The present experiments examined whether these characteristics hold for two so-called syllable-timed languages, Greek, in which stresses are irregular, and Korean, which completely lacks stress. In Greek, six speakers produced phrases differing in the regularity of their stress patterns. In Korean, nine-syllable phrases composed of three accentual phrases with varying numbers of syllables in each were used; in Experiment 1, speakers (N = 10) simply fitted each phrase repetition into metronome beat intervals (as Greek speakers did); in Experiment 2, speakers (N = 8) were additionally instructed to use a waltz rhythm. Speakers of both languages could perform the task keeping stable the phasing of stressed syllables (Greek) and accentual phrase initial syllables (Korean). Performance, however, was influence by each language's prosodic requirements: Greek speakers adjusted speaking rate to shorten long intervals between stresses, and deleted the first of two adjacent stresses; Korean speakers performed similarly in Experiments 1 and 2, since Korean does not allow prominence differences between accentual phrases. Overall, the results show that rhythmical speech is possible during cycling providing language-specific limitations are taken into account; if so, cycling can help us understand rhythm in speech and elucidate aspects of prosody cross-linguistically.

P2.5 Longitudinal trends in pause distributions in spoken texts

Hugo Quené
Utrecht inst of Linguistics, Utrecht University
Email: H.Quene@uu.nl

If a talker reads out a text, then she may time her pauses to convey a speech rhythm that may contribute to persuasive success. For example, a talker may tend to alternate longer and shorter pauses. Moreover, this rhythmic tendency may become stronger with age, since the aging talker has gained more experience in reading texts successfully. The present study explores such longitudinal trends in pause distributions in texts spoken by Queen Beatrix of the Netherlands, between ages 42 and 74. In these materials, Queen Beatrix produced short pauses of ~0.5 s duration, and long pauses of ~2.0 s. The odds of a pause being long was regressed on three predictors: the position within the text (in 3-minute bins), the short-vs-long category of the previous pause, and the year of the text.

First, the odds of a long pause do not change over the years. Secondly, there is an interaction between position and year. In earlier years, the odds increase within a text, whereas in later years the odds decrease. Thirdly, Queen Beatrix indeed tends to alternate short and long pauses: the odds are higher after a short pause. Finally, this preceding pause category interacts with year, so that the tendency to alternate short and long pauses becomes stronger longitudinally. These results suggest that Queen Beatrix times her pauses rhythmically, alternating short and long pauses, presumably for persuasive reasons. In addition, this rhythmical tendency becomes stronger with age and experience.

P2.6 Cross-linguistic analysis of speech rhythm with decomposition of the amplitude envelope

Sam Tilsen[1] & Amalia Arvaniti[2,3]
[1]*Cornell University* [2]*University of Kent* [3]*University of California, San Diego*
Email: a.arvaniti@kent.ac.uk

This paper presents a new approach to characterizing speech rhythm, based upon empirical mode decomposition (EMD) [Huang *et al.*, Proc. R. Soc. London Ser. A **454**, 903–995 (1998)]. Intrinsic mode functions (IMFs) are obtained from EMD of a vocalic energy envelope of speech, which is a smoothly varying signal, representing primary vocalic resonance energy. EMD uses an iterative sifting process to decompose the signal into IMFs with zero mean and zero-crossings between extrema. Investigations of IMFs revealed that the last two IMFs appear to capture foot-and syllable-timescale oscillations in the envelope, respectively, while the ratio of signal power in the foot- and syllable-associated IMFs can be used as a metric of the relative influence of foot-based timing on speech. EMD was applied to speech corpora of English, German, Greek, Italian, Korean, and Spanish obtained from eight speakers of each language with three elicitation methods: read isolated sentences, read running text, and spontaneous speech. For all languages, the metrics indicate that spontaneous speech exhibits more "stress-timing"-like characteristics than scripted read speech, having higher interval variability and more dominant stress-timescale periodicity in the envelope. Cross-linguistic differences emerged in some cases, but these were not entirely consistent across metrics and were affected by the elicitation method. Overall the data suggest that the elicitation effects (i.e., scripted versus spontaneous speech) are larger than differences between languages, while the similarities between languages indicate the presence of a common cross linguistic basis for speech rhythm quite likely related to foot structure.

P2.7 Many Moving as One? Analyses of movement synchrony within large groups

Mark T. Elliott[1], Feng Zheng[2], Vito Racic[2], James M. W. Brownjohn[3], Alan M. Wing[1]
[1]*University of Birmingham, School of Psychology, UK.*
[2]*University of Sheffield, Department of Civil and Structural Engineering, UK.* [3]*University of Exeter, College of Engineering, Mathematics and Physical Sciences, UK.*
Email: m.t.elliott@bham.ac.uk

Synchrony can often occur spontaneously within groups, where the size of the group can range from a pair of individuals (e.g. walking side-by-side) right up to large crowds (e.g. in football stadia, or walking across a bridge). While dyadic synchrony has been widely analysed, measuring synchrony within larger groups (n>2) becomes more complex and remains elusive. Here, I will present a range of analyses that can be applied to measure synchrony performance within groups. Using video and wireless inertial measurement units, we captured data from a group of 12 participants (stood in 4 rows x 3 formation) making bouncing movements. Movements were initially made in time to a metronome, which was then switched off. Participants bounced with eyes closed to begin with and then eyes open after the metronome was switched off. Using the experimental data, I will present analyses of synchrony performance at an individual and overall group level using event-based, frequency-domain and dynamical methods. In particular, I will show how the strength of synchrony coupling between individuals varies by position and the size of the group.

P2.8 Processing demands during the performance of rhythmic motor sequences

Hestermann, L. D., Wagemans, J., Krampe, R. T.
Department of Psychology, KU Leuven, Leuven Belgium
Email: hestermann@ppw.kuleuven.be

Previous studies on executive task management have shown that selection, implementation, and updating of mental-sets requires cognitive control. Processing demands for cognitive control increase when different sets compete for implementation in to a certain action. Krampe, Mayr & Kliegel (2005) proposed a cognitive control perspective on rhythmic timing inspired by the rhythm program hypothesis of Vorberg & Wing (1996). According to this model, rhythm programs are mental-sets representing the serial order and the relative duration of motor events (e.g. taps) in a sequence. In this ongoing study we investigate processing demands during the performance of rhythmic motor sequences. Participants learn different rhythms and are asked to produce them in a pure (one rhythm repeatedly) or a mixed (alternating between different rhythms) condition. In the latter condition we use an AABB paradigm to contrast effects of implementing a certain rhythm and switching between different rhythms. We also vary the degree of changes between rhythms and the point occurrence of the change in the sequence. We expect that competition between rhythm programs of consecutive sequences will lead to an increase in processing demands. In future studies we will investigate how cognitive control in rhythmic timing is affected by concurrent tasks and how rhythmic sequencing and finger sequencing interact. In addition, it is of great interest how chunking of motor sequences is affected by rhythm.

P2.9 Tempo in Baroque Music and Dance

Esther Coorevits[1] & Dirk Moelants[1,2]
[1] IPEM-Dept. Of Musicology, Ghent University, Belgium
[2] Dept. Of Musicology, University of Amsterdam, the Netherlands
Email: Dirk.Moelantds@ugent.be

Tempo is an essential aspect of dance performance. In baroque dance specific dance steps and the character of the different dances demand a specific tempo. However, in musical performance practice the tempo variation within one dance can be very large.

This study consists of two parts. In the first part musicians were asked to interpret a series of dances starting from the score. Later, dancers joined the ensemble and the evolution of tempo was measured. This showed that the musicians instantly adapt their tempo to the dancers, but that explicit feedback of the dancers is necessary to come to an optimal tempo.

In the second part of the study dancers are asked to make specific dance steps while the tempo of the music is varied. Both a measurement of their movements and a subjective evaluation of their experience were studied. The tempo restrictions for different steps were determined, as well as the optimal tempo based on the subjective evaluation of the dancers.

In general we see that the interpretation of baroque dance music by musicians does not always fit the original choreography and character. Yet, this study shows that tempo is an essential factor in historical performance practice. It provides a direct link between music and movement and thus gives a clear illustration of the importance of embodiment in music performance.

P2.10 The significance of verticality for musical entrainment

Hans T. Zeiner-Henriksen
Department of Musicology, University of Oslo
Email: h.t.zeiner-henriksen@imv.uio.no

Introduction: Head nodding, foot tapping and similar up-and-down movements are common corporeal responses in music listening. Principles of dynamic system theory (1, 2) and entrainment (3) may elucidate the underlying perceptual processes and clarify the function and structure of interacting rhythmic events in music that triggers such responses. Terms like "downbeat" and "upbeat", "ascending" and "descending" and "high" and "low" are often used in music. They point to a metaphoric relation to vertical directions (4). In a study of groove-based music there are several indications that indicate verticality as a significant force in rhythmic structures. (5). To what extent are there correspondences between patterns of bodily movement and vertical structures in musical grooves?

Method: Subjects: All of the music students affiliated with the Department of Musicology at the University of Oslo were invited by e-mail to answer a web-based questionnaire with music excerpts. Ninety-four students participated (response rate: 27.6%) (Age: mean: 26, SD=6.98. Female=44, male=49). Task: The respondents were asked to listen to 5 musical excerpts while moving their heads up-and-down and report the position of the head that corresponded with various rhythmic events (bass drum sounds, hi-hat sounds, etc.).

Results: The results show congruence in the movement pattern varying from 94.7% to 73,4% depending mainly on how apparent the verticality of the rhythmic structures was. Excerpts with many musical elements scored lower than excerpts with few.

Discussion: An awareness of the role of verticality in musical entrainment processes may lead to a better understanding of the complex interaction of different forces at play when music makes us move.

References

Thelen, E and Smith, L. B. 1994. A Dynamic Systems Approach to the Development of Cognition and Action.
Kelso, J. A. S. 1995. Dynamic Patterns: The Self-Organization of Brain and Behavior. (MIT press)
Jones, M. R. 2004. Attention and Timing. In Ecological Psychoacoustics, ed. J. G. Neuhoff. (Elsevier)
Zbikowski, L. M. 1998. Metaphor and Music Theory: Reflections from Cognitive Science. Music Theory Online 4 (1).
Zeiner-Henriksen, Hans T. 2010. The "PoumTchak" Pattern: Correspondences Between Rhythm, Sound and Movement in Electronic Dance Music. Ph.D. Thesis. University of Oslo.

P2.11 Exploring beat processing as a link between musical training and speech-in-noise perception

Kathryn M. Yates[1], Sygal Amitay[1], David R. Moore[1], Daniel E. Shub[2] and Johanna G. Barry[1]
[1]MRC Institute of Hearing Research, UK
[2]University of Nottingham, UK
Email: Kathryn@ihr.mrc.ac.uk

Musicians have an enhanced ability to perceive speech in background noise, and this has sparked interest in using musical training to rehabilitate people who struggle to understand speech in noise. However, given the varied nature of musical training, it is not clear which skills should be targeted. A preliminary investigation revealed a positive relationship between musical beat processing and speech-in-noise perception. We hypothesise that listeners with good beat perception are able to entrain to speech rhythms to predict word onsets. They therefore benefit from peaks in anticipatory attention which lead to enhanced processing of words that coincide with expected onsets. To investigate this hypothesis, two studies were conducted using rhythmic sequences to prime temporal expectations. In the first study, isochronous priming sequences were used to examine the effects of anticipatory attention on perception of targets in noise. Target stimuli were either pure tones (yes/no detection task) or monosyllabic words. As predicted, tone-detection and speech-reception thresholds for on-beat targets were significantly better than for earlier or later targets. In the second study, expectations were primed using more complex rhythms to examine whether the musical skill of entraining to an underlying beat can lead to greater benefit from anticipatory attention. As expected, the size of the priming effect due to these rhythms was significantly correlated with musical beat perception. These results demonstrate that anticipatory attention can enhance perception in noise. They also support the hypothesis that good beat perceivers might benefit from entraining to underlying rhythms when listening to speech in noise.

P2.12 ESP: ensemble synchronisation perception

Tim Yates[1], Satoshi Endo[2], Alan M. Wing[2]
[1] Health and Safety Executive, Buxton, United Kingdom
[2] School of Psychology, University of Birmingham, United Kingdom
Email: t.a.yates@bham.ac.uk

Individual variability in inter-note intervals (timing noise) results in asynchrony variance. Correction restores ensemble, reducing asynchrony variance. If the correction gains of a quartet vary, what difference does it make to the listener in a forced choice task?

Asynchrony variance can be equivalent for a low-correction, lower timing noise quartet and for an optimally adaptive, higher timing noise quartet. If the task was being performed using mean variance alone (i.e. without using higher order structure in the asynchrony), then variance at threshold should be the same for both experiments. If it is lower for experiment two, then the task must have been performed using higher order structure introduced by lower values of gain. Event times were generated by a modified Wing-Kristofferson model for a string quartet, combined with note pitch and duration information to create a midi file. The central noise and correction gain parameters were varied to generate target and testing stimuli for the task. Participants reported which of the two quartets performed an excerpt more accurately.

In the first experiment the target quartet had non-zero timing noise, and the timing noise of the test quartet was controlled by a staircase algorithm designed to converge on the level of noise that gives 75% correct performance. The threshold, $Th_{CENTRAL}$ was determined by fitting a logistic function to the psychometric data. In the second experiment the level of central timing noise in the target quartet was fixed at $Th_{CENTRAL}/2$, and the gain of the quartet at 75% correct performance level was calculated. Our preliminary results showed that asynchrony variance threshold in the second experiment was significantly lower than the first experiment indicating that people do not discriminate asynchrony using variance amplitude alone but the time-series of the asynchrony caused by a different gain was influencing how people interpret accuracy of quartet performance.