



ISCH Action TDo904
Time In MEntal activity: theoretical, behavioral, bioimaging and clinical perspectives (TIMELY)



TIMELY School on
“Timing and Time Perception: Procedures, Measures, & Applications”
Corfu (GR), February 4-8, 2013

Organized by Argiro Vatakis, Fuat Balci, & Georgios Papadelis

Local Organizer: Panayiotis Vlamos and Vassilios Chrysikopoulos, Dept. of Informatics, Ionian University

Andreas Floros, Dept. of Audio and Visual Arts, Ionian University

Information, Programme, Activities, & Abstracts

Location: The School will be held at the Dept. of Informatics [Πλατεία Τσιριγώτη 7] Room 3 of the Building Aretaios, Mental Hospital [Αίθουσα 3, κτίριο Αρεταίος, Ψυχιατρείο], location details can be found here <http://di.ionio.gr/en/contact/location.html>.

Access to the island of Corfu is possible either by air or by sea.

Travelling by air: The quickest way to reach Corfu is by air. There are domestic flights from Athens and Thessaloniki. The duration of the flight from Athens is about 50 minutes. The airport of Corfu, "Ioannis Kapodistrias", is located approximately 2 km from the city center and is easily accessed by taxi or bus (<http://www.corfu-airport.com/getting.html>).

Travelling by boat: Ferries leaving Patras and stop by Corfu before reaching Italy. From Italy (usually Brindisi) the same boats stop at Corfu before heading for Patras.

Participation: Free. Registration is required due to limited space (see below for contact details). All students participating are required to be present for the whole duration of the Training School.

For more information on the Training School or joining TIMELY: contact Argiro Vatakis at argiro.vatakis@gmail.com or visit www.timely-cost.eu.

DAY 1 – February 4th, 2013

11:00	Coffee & Welcome
11:30 – 14:30	Lecture & Lab Session: Production, reproduction, and verbal estimation of duration By J. Wearden
14:30-15:00	<i>[Poster preparation]</i>
15:00-17:00	Student Poster Session & Drinks
17:00-20:00	<i>MC Meeting [Closed session for TIMELY MCs]</i>
20:00	<i>Dinner at Anagnostiki</i>

DAY 2 – February 5th, 2013

9:00-13:30	<i>A tour of the city of Corfu</i>
13:30-17:00	Lecture & Lab Session: Clock, memory, and decision-making processes in duration-bisection and ordinal-comparison timing procedures By W. Meck & T. Penney
17:00-17:30	<i>Coffee Break</i>
17:30-20:30	Lecture & Lab Session: Peak procedure and differential reinforcement of low rates responding By F. Balci

DAY 3 – February 6th, 2013

9:30-10:00	<i>Coffee Break</i>
10:00-13:00	Lecture & Lab Session: Audiovisual simultaneity By M. DiLuca
13:00-15:30	<i>Lunch Break</i>
15:30-18:30	Lecture & Lab Session: Temporal Preparation By A. Correa
19:30	<i>Dinner at REX</i>

DAY 4 – February 7th, 2013

9:30-10:00	<i>Coffee Break</i>
10:00-12:30	Lecture & Lab Session: Measuring sensorimotor synchronization abilities By S. Dalla Bella
12:30-14:00	<i>Lunch Break</i>
14:00-16:00	Lab Session: MatTAP: A Matlab toolbox for sensorimotor synchronisation experiments. By M. T. Elliott
16:00-16:30	<i>Coffee Break</i>
16:30-17:30	Lecture & Demo Session: Nonverbal synchrony in social interaction: Assessment

and implications

By F. Ramseyer & W. Tschacher

17:30-18:30 **Lecture:** Synchronized Speaking: What speaking together can tell us about skilled action
By F. Cummins

DAY 5 – February 8th, 2013

9:30-10:00 *Coffee Break*

10:00-11:00 **Lecture:** The basic rhythmic resonance of our body around 2 Hz
By L. V. Noorden

11:00-12:00 **Lecture:** Measuring musical timing abilities in children
By G. Papadelis.

12:00-13:00 **Lecture:** Tracking a complex dance over time: Conversion of music to ballet over
34 weeks using fMRI.
By J. FX. DeSouza & R. Bar

13:00-14:30 *Lunch Break*

14:30-16:00 **Lab Session:** Rhythmologos: A battery for screening rhythm skills in
kindergarten and primary school children
By G. Papadelis

16:00-19:00 **Lab Session:** Measuring timing in ecological setting with portable equipment
By L. V. Noorden.

19:00 *End of Training School*

Activities & Abstracts

Production, reproduction, and verbal estimation of duration

John Wearden

Keele University, U.K.

Production, reproduction, and verbal estimation of duration represent a sort of “classic trio” of methods, used in time perception studies since the earliest days of the subject. The talk will discuss some of the different ways these procedures can be implemented, and some of the potential pitfalls in the use of each one. Among the issues discussed are (a) potential effects of feedback or calibration, and (b) the role of motor factors as “contaminants” of production and reproduction. Examples will be given of studies, which have used these methods, with a particular emphasis on the theoretical analysis of data obtained with all three methods.

Clock, Memory, and Decision-Making Processes in Duration-Bisection and Ordinal-Comparison Timing Procedures

Trevor B. Penney & Warren H. Meck

Department of Psychology, National University of Singapore, Singapore

Department of Psychology and Neuroscience, Duke University, Durham, NC, USA

Duration-bisection and ordinal-comparison timing procedures have been widely used to investigate the cognitive and neural substrates of interval timing in humans and other animals (e.g., birds, rodents, & primates). Experiments using these psychophysical procedures have revealed fundamental properties of interval timing such as modality differences in time perception, biases in the encoding and decoding of clock readings, and the continuity across species in the application of decision rules for the comparison of event durations. In the lecture component of the session, we will discuss the theoretical underpinnings of the duration-bisection and ordinal-comparison timing procedures in detail and review the primary empirical findings reported in the literature. In the practical component, students will analyze and interpret the data collected during the “hands on” session, as well as archival data.

Student Reading

Gu, B. M., & Meck, W. H. (2011). New perspectives on Vierordt’s law: Memory-mixing in ordinal temporal comparison tasks. *Lecture Notes in Computer Science*, 6789 LNAI, 67-78.

Lindbergh, C.A. & Kieffaber, P.D. (2012). The neural correlates of temporal judgments in the duration bisection task. *Neuropsychologia*, in press.

Penney, T. B., Gibbon, J., & Meck, W. H. (2000). Differential effects of auditory and visual signals on clock speed and temporal memory. *Journal of Experimental Psychology: Human Perception and Performance*, 26, 1770-1787.

Penney, T. B., Gibbon, J., & Meck, W. H. (2008). Categorical scaling of duration bisection in pigeons (*Columba livia*), mice (*Mus musculus*), and humans (*Homo sapiens*). *Psychological Science*, 19, 1103-1109.

Peak procedure and differential reinforcement of low rates of responding

Fuat Balci

Koç University, Turkey

In this presentation, two different interval timing tasks which can be used with both human and animal subjects will be discussed. First I will introduce the peak procedure, one of the most widely used tasks in the study of interval timing. Peak procedure is composed of two types of trials. In discrete fixed interval trials subjects receive a reward contingent upon their first response following a fixed interval since the onset of a conditioned stimulus. Whereas in peak trials, conditioned stimulus lasts much longer than the fixed interval trial, and responses are not reinforced. Multiple indices of timing performance can be gathered at both “molecular” and “molar” levels using this task. In the second part of my talk, I will introduce differential reinforcement of low rates of responding (DRL), which is a behavioral procedure that requires subjects to wait for a minimum fixed duration (since the previous response) before they can respond in order to receive a reward. Responding early restarts the trial with no reward, whereas a response that occurs following the minimum wait duration restarts the trial with a reward. Thus, reward maximization in this task relies on interval timing, level of timing uncertainty, and the ability to inhibit anticipatory responding. Differential reinforcement of low rates of responding has been widely used in the evaluation of putative antidepressants in psychopharmacology, and more recently it has been used in studies investigating temporal risk assessment. The procedural details of and analytical approaches for peak and DRL data will be introduced and discussed.

Student Reading

Balci, F., Freestone, D., Simen, P., de Souza, L., Cohen, J. D., & Holmes, P. (2011). Optimal temporal risk assessment. *Frontiers of Integrative Neuroscience*, 5(56), 1-15.

Rakitin, B. C., Gibbon, J., Penney, T. B., Malapani, C., Hinton, S. C., & Meck, W. H. (1998). Scalar expectancy theory and peak-Interval timing in humans. *Journal of Experimental Psychology: Animal Behavior Processes*, 24, 15-33.

Audiovisual simultaneity

Massimiliano Di Luca

University of Birmingham, UK.

Human observers acquire information about physical properties of the environment through different sensory modalities. Temporal coincidence of sensory information has been identified as an important cue to aid the organization of signals into a coherent representation. Perceived simultaneity, successiveness, and temporal order are thus important properties when dealing with multiple signals. Perceiving the correct timing of stimuli might seem a trivial problem presenting stimuli with an asynchrony that is opposite to the difference in delay should lead to perceived simultaneity. In reality, however this is hardly the case as physical and neural transmission times can differ greatly, there are stimulus dependent delays, partial compensations for differential delays, effects of adaptation, and cross modal influences that greatly complicate this relation. Here we will look at several basic methods to characterize perceive simultaneity of crossmodal stimuli so to be able to explore the influence of these effects.

Student Reading

Vroomen, J. & Keetels, M. (2010). Perception of intersensory synchrony: A tutorial review. *Attention, Perception, & Psychophysics*, 72 (4), 871-884.

Temporal preparation task Angel Correa

Departamento de Psicología Experimental, Universidad de Granada

This session aims to provide students with the fundamentals about the design, administration and analysis of a cognitive task to measure temporal preparation. Overview:

1. Lecture: Introduction to basic effects in temporal preparation (temporal orienting, rhythm-based preparation, foreperiod and sequential effects).
2. Lab Session:
 - 2.1. How to design a temporal preparation task with e-prime software.
 - 2.2. How to analyse data of a temporal preparation task.

Student Reading

Nobre, A. C., Correa, A., & Coull, J. (2007). The hazards of time. *Current Opinion in Neurobiology*, 17, 1-6. PDF

Triviño, M., Correa, A., Arnedo, M., & Lupiáñez, J. (2010). Temporal orienting deficit after prefrontal damage. *Brain*, 133, 1173-1185. TASK (download E-prime experiment)

* Note that this last reference also includes a link to my web where students can download the e-prime experiment that we will use in the lab session.

Measuring sensorimotor synchronization abilities Simone Dalla Bella

EuroMov, Movement to Health Laboratory, University of Montpellier-1

The ability to synchronize with an auditory stimulus (e.g., an isochronous sequence or music) is natural for the majority. This is visible when we spontaneously or deliberately move along with musical rhythm, or in synchronized sports. Sensorimotor synchronization can breakdown, however, in individuals with beat deafness or as a result of brain malfunctioning (e.g., in patients with neurodegenerative disorders, such as Parkinson's Disease). Various methods and models are used for the analysis of synchronization data, more or less appropriate for characterizing disorders of sensorimotor coupling. The most important methods and the underlying theories will be outlined with some examples. Particular attention will be paid to methods using circular statistics, as opposed to standard linear statistics, as a powerful way to detect impaired synchronization. In addition, a recent battery for testing sensorimotor abilities and time perception will be described (Battery for the Assessment of Auditory Sensorimotor and Timing Abilities, BAASTA; Farrugia et al., 2012).

Student Reading

Farrugia, N., Benoit, C-E., Harding, E., Kotz, S. A., Dalla Bella, S. (2012). BAASTA: Battery for the Assessment of Auditory Sensorimotor and Timing Abilities.

Repp, B. H. (2006). Musical synchronization. In E. Altenmüller, M. Wiesendanger, & J. Kesselring (Eds.), *Music, motor control, and the brain* (pp. 55–76). Oxford, UK: Oxford University Press.

Repp, B. H. (2005). Sensorimotor synchronization: a review of the tapping literature. *Psychonomic Bulletin Review*, 12(6), 969-992.

MatTAP: A Matlab toolbox for sensorimotor synchronisation experiments.

Mark T. Elliott

SyMoN Lab, School of Psychology, University of Birmingham, UK.

I will demonstrate a suite of tools, developed specifically for sensorimotor synchronisation and related experiments. The MatTAP toolbox allows flexible generation of high temporal accuracy cues, in the form of multiple metronomes, which can drive auditory, visual, tactile etc. stimuli. In addition, corresponding participant responses (e.g. finger taps) can be captured in parallel with the stimulus outputs. The integrated analysis module can subsequently be used to process results such as mean asynchrony. A simple graphical user interface is used to navigate the toolbox and so can be operated easily by users not familiar with programming languages.

MatTAP is written in the widely used MATLAB programming environment and usable with a range of data acquisition hardware. It is open source, fully extensible and customisable, allowing adaptation for individual experiments and facilitating the addition of new modules in future releases.

In the workshop, participants will learn how to run sensorimotor synchronisation experiments using the software and subsequently, analyse the data. Software will be available to install on participants' own laptops, while a full setup with data acquisition hardware will also be available for demonstration.

Student Reading

Elliott, M. T., Welchman, A. E., & Wing, A. M. (2009). MatTAP: A MATLAB toolbox for the control and analysis of movement synchronisation experiments. *Journal of Neuroscience Methods*, 177(1), 250-257.

Nonverbal synchrony in social interaction: Assessment and implications

Fabian Ramseyer & Wolfgang Tschacher

University Hospital of Psychiatry, Department of Psychotherapy, Switzerland

Background: The development and maintenance of social relationships requires good timing. Coordinative acts between partners are not restricted to logistic purposes; a good timing is manifested in different domains during any social interaction (e.g. turn-taking of speech behavior, coordination in nonverbal channels). Nonverbal behavior is affected by timing issues and it has an important impact on the quality and constancy of relationships. Traditionally, the assessment of nonverbal behavior has relied on labor-intensive manual coding of observable behavior, which has usually been done at the level of the individual. Our research is aimed at broadening traditional approaches by i) primarily focusing on the automatic assessment of nonverbal behavior, which ii) is manifested at the level of the dyad. One particular phenomenon of our interest is called nonverbal synchrony: the coordination of two or more people's body movement during social interaction.

Method: Nonverbal synchrony can be assessed from many kinds of recorded interactions with the aid of Motion Energy Analysis (MEA), an automated video-analysis procedure based on frame-differencing. MEA allows the objective quantification of movement patterns in pre-defined regions of interest. Any movement that occurs in such a region (e.g. head-movement, movement

of the upper body, etc.) is quantified as a time-series of movement intensity. From these time-series, one can derive individual global movement characteristics such as speed, duration, intensity, and complexity of movement. At the level of the dyad, these time-series are subjected to cross-correlation analyses: By calculating simultaneous and time-lagged cross-correlations (± 5 sec), we can identify moments of synchronized movement. In a further step, these results are compared with a bootstrap sample. This technique allows an objective quantification of nonverbal synchrony and provides a statistical estimate of the magnitude of the effect.

Results: We have used MEA to measure nonverbal synchrony in different types of psychotherapy sessions (dyadic therapy, couple therapy), in student encounters at zero acquaintance (collaborative and competitive task conditions) and in role-play sessions with patients suffering from schizophrenia. In all settings, nonverbal synchrony was significantly higher compared to the bootstrap samples. Furthermore, we found associations between nonverbal synchrony and relationship quality, interpersonal characteristics, psychopathology, and interaction outcome. Nonverbal synchrony was positively associated with successful social interaction.

Conclusions: Our data from a multitude of settings indicate that nonverbal behavior in social interaction embodies important aspects of social relationships: Short-term outcome (assessed after the interaction), long-term outcome (assessed after therapy/ after the experiment), and personality factors (from questionnaire data) are positively associated with nonverbal synchrony. Using automated assessments such as Motion Energy Analysis allows fast, objective and reliable quantifications of nonverbal behavior, which are open to be used in many different research designs.

Student Reading

Ramseyer, F., & Tschacher, W. (2011). Nonverbal synchrony in psychotherapy: Coordinated body-movement reflects relationship quality and outcome. *Journal of Consulting and Clinical Psychology*, 79(3), 284-295.

Ramseyer, F., & Tschacher, W. (2010). Nonverbal synchrony or random coincidence? How to tell the difference. In A. Esposito, N. Campbell, C. Vogel, A. Hussain, & A. Nijholt (Eds.), *Development of multimodal interfaces: Active listening and synchrony* (pp. 182-96). Berlin: Springer.

Synchronized Speaking: What speaking together can tell us about skilled action

Fred Cummins

UCD School of Computer Science and Informatics, University College Dublin, Ireland

Speech has conventionally been considered as the kind of thing that is done by one person at a time. Yet there are many situations in which we speak by saying the same thing at the same time: in classrooms, churches, temples, sports stadia, and on the street. Joint speaking has not yet been subject to scientific study, which is surprising, given its rich embedding in cultural and educational practices throughout the world. There are many questions we may ask in this domain. A laboratory variant of joint speaking, which I call Synchronous Speech, has revealed some characteristics of joint speech that are of potential interest to phoneticians and cognitive scientists. Speakers can speak fluently while remaining in very tight synchrony with a cospeaker, even when reading novel texts. This particular form of synchronized action has some characteristics that make it different from every other case in which people synchronize skilled action. I will suggest that we might begin to develop an account in which two synchronized speakers are usefully regarded as a transiently assembled single system, rather than as two entirely separate systems.

Student Reading

Cummins, F. (2012). Periodic and aperiodic synchronization in skilled action. *Frontiers in Human Neuroscience*: 5:170.

The basic rhythmic resonance of our body around 2 Hz

Leon van Noorden

IPEM, UGent

In 1999 Van Noorden and Moelants have shown that many phenomena in rhythm perception and production can be explained by a resonance in our perception-action system around 2 Hz. Examples of these phenomena are: subjective rhythmisation, the existence region of musical pulse, tapping tempo preferences in polyrhythmic metronomes. This resonance is reflected in the tempo histogrammes of the pulse of musical pieces.

In 2005 McDougal and Moore showed that the spectrum of spontaneous daily movement activities has also a strong peak around 2 Hz. They linked their results to our work on the tempo histogramme of musical pulse. This link triggered our work on walking and tapping to music around 2 Hz. The types of questions that we addressed are: Where is the resonance of the spontaneous movement located: in the bio-mechanics of the body or in the control mechanism of our movements or in both; Do young children have the same resonance or does it emerge gradually or does it change in the resonance frequency; Does the synchronisation in our repetitive movements occur spontaneously or does it need attention; What else is linked to the 2 Hz resonance.: is it just walking or are there links with e.g. rocking a baby to sleep; Does the resonance play a role in the precision of tapping, etc.

The main focus of the lecture will be on our experiments on walking to music: 1. by adults, addressing both the influence of music on walking under the instruction to synchronise to the music and under no instruction at all in order to find the spontaneous response. 2. The tapping to childrens songs of 424 children in the age range from 3 to 11 years old the find the relation between synchronisation and resonance in a developmental context.

Some reference will be made to our experiments on the beneficial aspects of music for Parkinson patients and in the context of sport activities.

In the practical session we will propose to perform rhythmical activities, such as alternating hand clapping in different group sizes, between 2 and all the participants of the training school. The registrations of these clapping exercises will then be analysed by some non-linear time series analysis techniques, such as return maps.

References

van Noorden, L., & Moelants, D. (1999). Resonance in the Perception of Musical Pulse. *Journal of New Music Research*. Routledge.

MacDougall, H. G., & Moore, S. T. (2005). Marching to the beat of the same drummer: the spontaneous tempo of human locomotion. *Journal of Applied Physiology*, 99(3), 1164-1173. Am Physiological Soc.

Styns, F., van Noorden, L., Moelants, D., & Leman, M. (2007). Walking on music. *Human Movement Science*, 26(5), 769-785. Elsevier.

Abarbanel, H. D. I. (1996). *Analysis of Observed Chaotic Data*. Springer.

Tracking a complex dance over time: conversion of music to ballet over 34 weeks using fMRI

Joseph FX DeSouza & Rachel Bar

Centre for Vision Research, Department of Psychology, Biology and Neuroscience Graduate Diploma Program, York University, Toronto, CA

We were interested in examining the time course of the evolution when beginning to learn a new dance to a novel piece of music and its associated neural changes in the brain. To date we have scanned twelve professional dancers from the National Ballet of Canada with nine control dancers. Today I will talk about the first cohort of five professional dancers who participated in four fMRI scanning sessions over eight months of the ballet season. We scanned the dancers four times while learning and performing a new choreographed piece. We examined their brain activation by playing the same 1-minute piece of music employing a blocked design (5 epochs of 1 minute with alternations of a 30-sec fixation period) at four time points over 34-weeks. Subjects were asked to visualize dancing their part while listening to this piece of music (see reading of Leonardo et al 1995). At the time of the first scanning session, 4 rehearsals of the piece was learned. The control subjects were also tested at this time period but they had no rehearsals and had no exposure to the music before scanning. The second scanning session occurred one week later, after a total of 9 rehearsals. The third scanning session was completed 7 weeks after initial acquisition of the dance (at this point the dance was performed a total of 16 times after initial training). At the last scanning session (34-weeks) the professional dancers performed the dance a total of 32 times. Additionally a control motor localizer was performed in each scanning session to activate motor regions that should not change activation patterns across all four scanning sessions. Results revealed a significant increase of BOLD signal, across the sessions in a network of brain regions including bilateral auditory cortex to supplementary motor cortex over the first three imaging sessions but a reduction in the fourth at 34-weeks. This reduction in activity was not observed in basal ganglia (caudate nucleus). These results suggest that as we learn a motor sequence in time to music, neuronal activity increases until 7 weeks and then decreases at 34-weeks, possibly when it is overlearned, but in contrast the BG activation is maintained at least until 34-weeks. Over this lecture we will examine many aspects of time within the 1-minute piece of music and over the 34-weeks of performance as well as using this paradigm as a tool for examining cortical plasticity in normal and people with brain disease (see Page et al 2009 reading).

Student Reading

Leonardo, M., Fieldman, J., Sadato, N., Campbell, G., Ibañez, V., Cohen, L., Deiber, M-P., Jezzard, P., Pons, T., Turner, R., Le Bihan, D., & Hallett, M. (1995). A functional magnetic resonance imaging study of cortical regions associated with motor task execution and motor ideation in humans. *Human Brain Mapping* 3, 83-92.

Page, S. J., Szaflarski, J. P., Eliassen, J. C., Pan, H., & Cramer, S. C. (2009). Cortical plasticity following motor skill learning during mental practice in Stroke. *Neurorehabilitation and Neural Repair*, 23(4), 382-388.

Student Abstracts

Visualize Sound

Aris Bezas

AudioVisual Arts Department of Ionian University

Live AudioVisual performance by extracting sound characteristics (FFT - Spectrograph Data, Loudness, Onsets detector, Spectral centroid, Spectral Flatness measure) received from a microphone.

The oddball effect in vision and audition: Does the judgment type influence the overestimation of rare stimuli?

Teresa Birngruber¹, Hannes Schröter¹, & Rolf Ulrich¹

¹University of Tuebingen, Germany

The duration of rare deviant stimuli (oddballs) within a series of homogenous stimuli is often overestimated, an effect referred to as oddball effect (OE, Tse et al., 2004; Ulrich et al., 2006). The OE is usually attributed to perceptual processes. However, the usually employed comparative judgment task might be prone to a decision bias and thus, the OE could be an artifact. We checked for this alternative explanation by comparing two different psychophysical tasks, the classical comparative judgment and an equality judgment. In the first experiment, participants were asked to judge whether the duration of a visual oddball (e.g. blue circle) presented within a series of standards (e.g., red circles) was shorter/ longer (comparative judgment) or equal/ unequal (equality judgment) than the duration of the standards. We observed a reliable OE of about 30 ms, which was not influenced by judgment type. In the second experiment, we replicated this pattern of results for auditory stimuli. Since the equality judgment should be resistant to decision biases (Schneider & Komlos, 2008), these results suggest that the OE for both visual and auditory stimuli originates from perceptual processes. Possible theoretical implications and follow-up studies are discussed.

Schneider, K. A., & Komlos, M. (2008). Attention biases decisions but does not alter appearance. Journal of Vision, 8, 1-10.

Tse, P. U., Intriligator, J., Rivest, J., & Cavanagh, P. (2004). Attention and the subjective expansion of time. Perception & Psychophysics, 66, 1171-1189.

Ulrich, R., Nitschke, J., & Rammsayer, T. (2006). Perceived duration of expected and unexpected stimuli. Psychological Research, 70, 77-87.

Electrophysiological correlates of temporal sequential effects

Mariagrazia Capizzi¹, Daniel Sanabria¹, Ángel Correa¹, Nicolas Rochet² & Boris Burle²

¹Departamento de Psicología Experimental, Granada, Spain

²Laboratoire de Neurobiologie de la Cognition, Aix-Marseille Université, CNRS, Marseille, France

The main goal of the present study was to investigate the electrophysiological correlates of temporal sequential effects in the context of a variable foreperiod design. Sequential effects refer to

the finding of faster responses at current short foreperiods when current and previous foreperiod match in duration (i.e., short-short sequence) than when they mismatch (long-short sequence). By contrast, on current long trials, participants' responses are equally fast for both repeating and alternating foreperiods (long-long sequence versus short-long sequence). Previous studies have related sequential effects to motor arousal or conditioning mechanisms operating on previous trials. Together with effects at the P₃ potential, we report evidence that sequential effects may also optimize behaviour by enhancing early perceptual processing stages as indexed by the P₁ potential.

The Effect of Musical Rhythm on Sentence Perception: auditory vs. auditory-motor engagement

Nia Cason¹, Corine Astésano² & Daniele Schön¹

¹Université Aix-Marseille II, INSERM U 1106 /Institut de neurosciences des systems; ²Laboratoire Parole et Langage UMR 7309 CNRS - Université Aix-Marseille

Rhythm perception is a motor phenomenon (Grahn and Brett, 2007), which engages areas involved in rhythmic movement production (Jäncke et al., 2000), and areas involved in auditory-motor interaction (Chen et al., 2008). Auditory rhythm is therefore thought to enhance sensorimotor connectivity, and this entrainment of the motor system to auditory rhythm may result in the fluency-enhancing effect of rhythm in non-fluent populations (Stahl et al., 2011).

At a finer level, neuronal populations are thought to resonate at the same frequency as a heard rhythm (Jones & Boltz, 1989; Large and Jones, 1999; Snyder and Large, 2005) and this neural entrainment is thought to result in an enhanced perception for events occurring at temporally predictable positions (Large & Jones, 1999). For instance, it has been found that the alignment of linguistic with musical meter means both beat tracking and comprehension of lyrics is enhanced (Gordon et al., 2011). Rhythmic speech also results in an enhanced processing of syntactic and semantic information (Rothermich et al., 2012; Schmidt-Kassow & Kotz, 2011).

In a behavioural/EEG study, we previously found that musical rhythm can also exert an effect on speech processing in a cross-domain manner (Cason & Schön, 2012). Beat expectations induced by musical rhythm influenced the subsequent processing of spoken words (phonological processing). In the current study, we investigated whether the processing of spoken sentences can also be enhanced through inducing temporal expectations, and whether motor engagement with a metrical rhythm has an advantage over passive listening. In the passive listening group, participants heard metrical rhythms, which were either matched or mismatched to a sentence, which followed. In the motor engagement group, participants completed the same task but underwent an additional training period in which they were required to reproduce the musical rhythm presented. This research is relevant if we consider populations undergoing speech therapy. For instance, the verbo-tonal method includes motor engagement during speech training, whilst other rhythmic speech therapies may not. Considering that speech is a skill requiring auditory-motor integration, a training stimulus which enhances sensorimotor synchronisation (motor engagement with musical rhythm) may be more effective in enhancing speech perception and production than one which requires auditory engagement alone.

The mechanisms of Space-Time association: Comparing motor and perceptual contributions in Time Estimation

Nicola Cellini¹, Marco Fabbri², Monica Martoniz², Lorenzo Tonetti², & Vincenzo Natale²

¹ Department of General Psychology, University of Padua, Italy

² Department of Psychology, University of Bologna, Italy

Time and space are deeply related in the physical world. Growing experimental evidence suggests that temporal events are represented on a mental time line (MTL), spatially oriented from left to right. According to task characteristics, the spatial representation of time can be linked to different types of dimensions including manual response codes (i.e. the Spatial-Temporal Association of Response Codes - STEARC) and physical space codes (i.e. the position of a stimulus in the physical space). It is unclear whether this spatial-temporal association is mainly related to a perceptual, to a motor or to an interaction of these two components. The aim of the present study was to analyze whether manual response and physical space codes are independent from each other or they interacted when both types of information are involved in a temporal estimation task. Through four experiments, participants were requested to perform the task with two lateralized response buttons, in order to detect the STEARC effect. In addition, in order to consider the perceptual component, reference and target stimuli were presented in different spaces through the experiments. In the first experiment, the target stimuli were presented on the left, center or right side of the space, while the reference stimuli were always presented centrally. The reverse situation was presented in the second experiment. In the third experiment, both stimuli were presented in opposite spatial positions (e.g., left-right), while in the last experiment, both stimuli were presented in the same spatial position (e.g., left-left). In Experiments 1-3, the performance was better when both manual response and physical space codes were congruent with the durations to be judged than when only manual response codes were congruent (and physical space codes were either incongruent or absent) with the durations. In Experiment 4, this interactive effect between both codes disappeared. The results indicate that the physical spatial codes interact with the manual response codes when the task characteristics involved spatial information of both perceptual and motor components, suggesting that they are not completely independent from each other.

Aging and dual-task walking: new findings in support of cognitive compensation in older adults

Leslie M. Decker^{1,*}, Fabien Cignetti¹, Jane F. Potter², Stephanie A. Studenski³, Nicholas Stergiou^{1,4}

¹Nebraska Biomechanics Core Facility, University of Nebraska at Omaha, Omaha, Nebraska, USA.

²Division of Geriatrics, University of Nebraska Medical Center, Omaha, Nebraska, USA.

³Division of Geriatric Medicine, University of Pittsburgh, Pittsburgh, Pennsylvania, USA.

⁴College of Public Health Department, University of Nebraska Medical Center, Omaha, Nebraska, USA.

A usual way to assess the extent to which gait places demands on cognitive resources is to examine the individuals' ability for dual tasking, which consists in walking while simultaneously performing a secondary cognitive task. Overall, studies reported age-related dual-task deficits while walking, involving larger decrements in gait performance in older adults (OA) than in young adults (YA). A likely explanation for these results is that gait control increasingly relies on cognitive processes with aging while at the same time attention capacity and other relevant cognitive resources are reduced. Most previous studies are, however, limited by the fact that the walking task was not goal-directed. Indeed, without a clearly defined goal, reaching a conclusion as to whether dual-task-dependent

gait changes reflect or not suboptimal solutions for completing the walking task is tricky. To address this issue, we conducted a series of experiments where YA and OA performed dual-task treadmill walking, whose goal is to maintain constant walking speed. Our results indicate that OA maintained more robust strategies than YA to achieve treadmill walking requirements when dual tasking, likely reflecting a beneficial effect of cognitive activities on gait control. We propose that OA might have relied on neural compensation to stabilize dual-task performance.

Attention and Causal Binding

Alison Dennehy & Marc Buehner
Cardiff University

Our experience of time can be distorted by a wide array of circumstances and events. It has recently been found that when two events occur that are causally related, the interval between them appears shortened in comparison to two events that are not causally related. The aim of my research is to uncover the mechanisms behind this phenomenon. More specifically, my research project will investigate to what extent attentional processes are implicated in the 'causal binding' effect. It is well recognised that the less attention that is paid to time, the faster time appears to go. It could be, then, that causal binding occurs due to attention being taken away from time passing and directed elsewhere. This may be because the presence of a causal relationship enables one to make better predictions about what will happen. This in turn means less attention is required to anticipate future events, and additional attentional resources can be deployed to other aspects of the environment. To this end, my first experiment will involve having participants take part in a causal binding task whilst also conducting a concurrent incidental memory task. Causal binding tasks usually involve a causal and a non-causal condition. In the causal condition, there are two events, one of which causes the other. In the non-causal condition, there the same two events but there is no causal connection between them. In addition to this, in my experiment, participants will be presented with stimuli unrelated to the task at hand, such as faces, words, or pictures during the interval between the two events and they will be tested on their memory for these items at the end. I predict that, if it is the case that causal binding is due to attention being directed away from time passing, that participants' memory for items presented to them alongside the causal binding task, will be better in a causal condition than a non-causal condition.

Temporal characteristics of emotionally annotated sound events

Konstantinos Drossos & Andreas Floros
Audiovisual Arts, Ionian University

Apart from the main properties of communication with ones environment, sound can also convey emotion(s) to the listener. Which specific emotion, or emotions, will the listener perceive depends on various characteristics of the sound source and the sound it self. Music emotion recognition is one of the main applications of emotion recognition through sound/audio, resulting in the emerging field of music emotion recognition (MER) and with applications to Music Information Retrieval (MIR) field. But sound is not only music. The present poster in concerned with non-musical sounds and non-linguistic sounds, i.e. sound events, and the connection of their temporal characteristics with the emotions perceived by the listeners. As a database is used the International Affective Digital

Sounds (IADS) database, as the only, to authors' knowledge, emotionally annotated sound events database. Various temporal characteristics are extracted from the IADS and an information evaluation for each of them is performed using feature selection functionality of WEKA software.

Altered interstimulus interval's effects on Time Perception

Ceyla Erhan

Koc University

Predictability and attentional theories explain the perceived duration alterations in response to novel vs. familiar stimuli. Neural models, such as repetition suppression, support predictability theory by explaining the phenomenon: As stimuli are repeated there is a reduction in the neural response. The goal of this study is to answer the question of what happens to time perception when novel vs. familiar stimuli are presented. The study will further investigate what happens to the subjective perceived time of stimuli when interstimulus intervals (ISIs) are altered. The proposed study is formed of two experiments, in both of which the durations and the shapes of the stimuli are kept constant. The ISIs are kept constant in the first experiment but altered purposefully in the second experiment. The hypothesis is that the change in the ISIs will cause a change in the perceived time of the stimuli; however the direction of the change is not predicted.

Auditory temporal prediction and Parkinson's disease: Effects on early ERPs and oscillations

Nicolas Farrugia¹, Charles-Etienne Benoit^{1,2}, Michael Schwartz¹, Simone Dalla Bella ^{2, 3,4} & Sonja A. Kotz¹

¹ Max Planck Institute for Human Cognitive and Brain Sciences, Independent research group «Subcortical contributions to comprehension», Stephanstrasse 1a, 04103 Leipzig, Germany

² Department of Cognitive Psychology, University of Finance and Management in Warsaw, Ul. Pawia 55, 01-030 Warsaw, Poland

³ EuroMov, Movement to Health (M2H) Laboratory, Montpellier-1 University, 700 Avenue du Pic Saint Loup, 34090 Montpellier, France

⁴ International Laboratory for Brain, Music, and Sound Research (BRAMS) 1430, boul. du Mont-Royal (Outremont), Montréal H2V 4P3 Canada

Temporal regularity of sensory information coming from the environment enables humans to better predict upcoming events. Studying how the brain takes advantage of such regularity paves the way for better understanding deficient temporal processing in Parkinson's disease. There is evidence from psychophysics and neuroimaging that these deficits may be related to impaired subcortical connectivity involving the basal ganglia, the thalamus and a number of cortical sites such as the SMA and prefrontal cortex. This also implies that neurodegeneration within such a network could be reflected in the time course of brain signals as a temporally plausible correlate involving subcortical structures. In the current study we investigated early electrophysiological contributions to temporal processing in PD patients. 20 patients (Hoehn and Yahr scale 2 to 3) and matched healthy controls were tested in an attentive auditory perception task using EEG, in which temporally regular (inter-stimulus-interval, ISI = 800 ms) and irregular (random 200-1000 ms ISI) oddball sequences were presented. The sequences consisted of 360 standard (600 Hz) and 90 deviant (660 Hz)

equidurational (200 ms) sinusoidal tones. Participants' task was to count the deviant tones. In a previous similar study with young healthy participants we were able to show that the P50 and N100 ERP components were both sensitive to temporal regularity in attentive settings (Schwartz, Farrugia & Kotz 2012). We aimed to reproduce and extend these findings by examining the relationship between the ongoing phase of oscillations at stimulus onset and the generation of ERPs, and to investigate how Parkinson's disease affected these early electrophysiological markers. First ERP analyses show that the P50 amplitude is sensitive to temporal structure both in patients and controls. However, in the N100 window, healthy controls still display an effect of temporal regularity, while patients show a qualitatively different N100 pattern: the overall amplitude is reduced and the N100 response delayed relative to controls, with an additional negativity around 130 ms only elicited with irregular sequences. These findings suggest that PD patients may still benefit from temporal structure during early stages of perception as reflected by the P50 effect, while later N100 responses are altered, and possibly engage distinct neural resources compared to healthy participants in the processing of temporally irregular sequences. In future analysis, we will investigate to what extent these ERP results can be explained by the phase of theta and alpha oscillations at stimulus onset, thus addressing the question whether the observed ERP effects can be linked to differing levels of neuronal excitability.

Causal binding and internal clocks: Is slowing of time general or sensory specific?

Fereday, R., Buehner, M. J., & Rushton, S. K.
Cardiff University

The perception of time is inherently subjective. The rate of passage of time increases or decreases according to various factors. Theories that account for temporal distortion include event perception theories and internal clock theories. An event perception theory posits a lag between sensory streams that is recalibrated to ensure a unitary percept. Alternatively, an internal clock theory assumes a consistent emission of time pulses that accumulate in a pacemaker. A time perception illusion that has recently received considerable attention is the 'temporal binding' effect, which refers to the subjective contraction of time between an action and its effect. How might this binding effect be reconciled with current theories of time and event perception? An event perception theory would predict a pre-dating of one sensory stream relative to another, such that the experienced time of an action or outcome is altered. An internal clock theory would predict a momentary decrease in clock rate. A recent study (Wenke and Haggard, 2009) found support for the latter. The study employed a temporal discrimination task during a binding interval, using tactile shocks. Participants reported whether the shocks were concurrent or consecutive. If a decrease in clock rate occurs in a binding interval then temporal resolution is impaired, because fewer pulses result in larger bin sizes. There is, in turn, the increased likelihood of two stimuli falling within the same bin. In line with these predictions, temporal discrimination was poorer during binding trials than during control trials. The present study aims to extend this finding by investigating the clock-slowness effect as a general sensory property. Visual flicker fusion stimuli will be presented for brief durations during a binding task. A higher threshold of discrimination for the visual stimuli will reflect a decrease in clock rate. More importantly, this study investigates whether a general decrease in subjective time, rather than a sensory specific (tactile) response, will underpin the binding effect. Further application of the paradigm to a causal binding task will support 'clock-slowness' as a function of causality (over and above motor control) in general. Overall, the study investigates the (mutual) relations between time perception and causality.

The effect of practice on behavioral sensitivity to temporal and numerical stimuli using the Bisection Task

Fernandes, E., Kroger-Costa, A., Tonneau, F., & Machado, A.
University of Minho, Braga, PT

Our study aims to investigate how sensitivity to temporal and numerical stimuli improves with practice and, additionally, whether exposition to the test stimuli or to a discriminative training procedure leads to differentiated degrees of improvement. We compare human performance in bisection tasks that either precede or follow a discriminative training procedure or simply the presentation of the relevant stimuli. The experiment comprises three phases: (1) Baseline or 1st Bisection task, (2) Treatment, and (3) Test or 2nd Bisection task. During Baseline, human adults are exposed to a standard bisection procedure in which after learning the correct assignments between each anchor stimulus and a response ("Short" or "Long"), they are tested with intermediate stimuli. Participants are then divided into three groups during the Treatment phase: those in the (2.1) Exposure group are presented the stimuli used in the bisection phase; those in the (2.2) Training group are presented the stimuli but, on each trial, instead of classifying the stimuli as "Short"/"Long", they are trained to select an appropriate figure amongst five figures (red square, blue triangle, etc.); the (2.3) Control group does not entail a treatment, merely a delay that equates the other two groups' experimental time. The final Test phase repeats the events of the first bisection session.

Individual performance in the Test phase (2nd bisection session) will be contrasted to the Baseline, in sensitivity (Weber Ratio) and bias (Point of Subjective Equality). We also analyze inter-subject differences across the three treatment groups. Due to the growing evidence of the similarity in mechanisms of time and numerical discrimination, the experiment will be conducted using temporal and numerical stimuli. These results will be discussed in the light of current theories of timing and number discrimination.

Intersensory temporal association before consciousness

Jordi Navarra¹, Iruñe Fernández-Prieto^{1 2}, Joel García-Morera¹ & Rubén Moreno-Bote¹

¹Parc Sanitari de Sant Joan de Déu, Fundació Sant Joan de Déu, Esplugues de Llobregat (Barcelona), Spain.

²University of Barcelona

To what extent does our unconscious experience with a temporal correspondence between two stimuli from different modalities influence how we subsequently perceive them? We addressed this question by exposing participants two different geometrical figures (a circle and a triangle; presented unpredictably) and a tone, for 5min. While the circle was consistently presented 700ms before the tone, the triangle always appeared in a completely uncorrelated fashion with respect to the tone. In two test blocks, conducted one before and the other one after the 5-min exposure phase, participants performed simultaneity judgments (SJs) regarding the circle and the exposed tone or else the triangle and the tone presented at different stimulus onset asynchronies (SOAs). The results revealed that, even if participants were unable to detect any conscious association between the stimuli presented after the 5-min exposure phase, they significantly accepted less time between the 'associated figure' (the circle) and the tone than between the 'non-associated figure'

(the triangle) and the tone to judge them as being simultaneous, after exposure. This pattern of results indicates that the preconscious establishment of perceptual links between visual and auditory signals modulates the subjective temporal perception of these signals.

Gait analysis in Autism: A potential diagnostic tool

Kitty Forster & Dawn Wimpory

*Bangor University Psychology Department, Bangor, Wales, United Kingdom.
Betsi Cadwaladr University Health Board, National Health Service, Wales.*

Autism Spectrum Disorder is a complex disorder, with theories implicating clock genes, cerebellum, basal ganglia, purkinje cell and inferior-olive anomalies in explaining the aetiology. The basal ganglia influence in Parkinson's Disease and, similarly, cerebellar ataxic gait research has demonstrated comparable timing inconsistencies in the gait of people with autism, reinforcing neurobiological theories. The neurodevelopment of these areas of the brain are influenced by the genes which govern circadian rhythms in mammals; 'clock genes'. Extensive empirical evidence has shown timing inconsistencies of many types from conducting gait analysis on people with autism. Using a superior technological measure; a VICON 3-D Motion Capture System, we recruited 6 [and counting] male participants with High Functioning Autism between the ages of 7-30, with age-match controls and examined the timing within each step to a precision of milliseconds. If a significant result is obtained, gait analysis could ultimately add to the repertoire of a psychologist diagnosing autism, to provide support for families sooner.

Identification of Temporal Processing Domains Relevant to Assessment of Psychotic Illness: Development of the Integrity of Temporal Processing (ITP) Battery

Sarah E. Forster, Ryan J. Lackner, & William P. Hetrick

Indiana University, Department of Psychological and Brain Sciences

Efforts to identify a common denominator in the characteristically heterogeneous clinical presentation of schizophrenia have prompted the suggestion that a disturbance of temporal processing may underlie positive, negative, and disorganized dimensions of schizopathology (Fuchs, 2007; Andreasen, 1999). According to this perspective, the abnormal perceptual experiences, disorganized thought, and disordered behavior that typify schizophrenia can be attributed to a fundamental failure in the temporal coordination of sensory, cognitive, and motor processes. Similarly, a central disturbance of temporal processing integrity may also provide a common provenance for the diversity of cognitive deficits observed in conjunction with the disorder and thought to be integral to long term functional impairment. While a recent impetus to discern mechanisms of cognitive dysfunction in schizophrenia has spurred a movement to efficiently and consistently characterize specific domains of impairment (Green, et al., 2004; Carter, et al., 2008), resulting assessment tools have heretofore omitted assessment of temporal processing ability. The current study aims to address this gap in measurement by developing a standardized battery for the assessment of temporal processing dysfunction in schizophrenia-spectrum psychopathology. In order to achieve a comprehensive assessment tool, task selection was informed by an extant dimensional analysis of timing ability (Rammsayer & Brandler, 2004) and review of relevant neuroimaging findings (Lewis & Miall, 2003; Penney & Vaitilingam, 2008; Wiener, Turkeltaub, &

Coslett, 2010; Coull & Nobre, 2008). Specifically, tasks probing timing ability across sub- and supra-second, motor and non-motor, and implicit/predictive vs. explicit/reflective domains were selected for inclusion. The first wave of the current study will entail administration of eight temporal processing tasks to a sample of 60 healthy individuals and 40 individuals with schizotypal personality traits. Temporal processing tasks will include: magnitude estimation, temporal bisection, temporal reproduction, finger tapping, method of dynamic stimuli, auditory flutter fusion, temporal order judgment, and velocity judgment. Principal components analysis will be conducted to identify tasks assessing unique dimensions of temporal processing function. Self report assessment of schizotypy, perceptual anomalies, and temporal context memory will also be conducted and cognitive measures will include assessment of fluid intelligence, executive working memory, inhibitory control, task-switching, and semantic fluency. A post hoc correlational analysis will aim to identify dimensions of temporal processing ability that best correspond with cognitive functioning and/or other clinically-relevant variables. Preliminary findings will be presented and discussed.

Effect of temporal adaptation on actions to integrated multisensory stimuli

Vanessa Harrar¹, Charles Spence¹, & Laurence R. Harris²

1. *Department of Experimental Psychology, University of Oxford, United Kingdom*
2. *Psychology Department, York University, Canada*

Our ability to combine sensory information across modalities can improve performance; in particular, we react more rapidly to audiovisual stimuli than to either stimulus presented on its own. Improved performance for multisensory stimuli can be predicted on the basis of a simple statistical summation (the race model, or Miller's inequality [1]), but there may be a reaction time (RT) advantage over-and-above this statistical prediction, which, if present, provides evidence that the component signals are not completely independent (i.e. have been integrated, see violations of Miller's inequality, e.g. [2]). Multisensory integration is more likely when the stimuli are synchronous [3]. Correspondingly, the largest violations of Miller's inequality are observed when stimuli are presented synchronously. Repeated exposure to temporally offset multisensory stimuli can change the perceived delay between the stimuli so that synchrony is perceived as closer to the adapted delay rather than real synchrony [4]. If the perception of synchrony is adaptable, might the point (or delay) of maximal integration also be altered after adaptation? While perception of synchrony is learned, and can be reprogrammed, it has yet to be determined whether the signals used to generate actions (and reactions) can also be reprogrammed by a few minutes exposure to asynchronous signals. Temporal adaptation has been suggested to change the processing speeds of the component stimuli [5-6], which should alter perception and action. Alternatively, if the perception of synchrony is a higher/cognitive function, then actions might not be as adaptable as perceptions; in this case the point of maximum integration (that is, the maximum violation of Miller's inequality) might remain at true simultaneity rather than the delay associated with perceived simultaneity. To investigate this, we measured RTs to unimodal visual, auditory, and combined audiovisual stimuli after adaptation to synchronous or asynchronous (auditory lagging by zooms) stimulus pairs. Results were compared to Miller's expected statistical inequality calculated for each adaptation condition from the unisensory RTs. The results are discussed in the context of perception versus action and current models of multisensory integration.

1. Miller JO (1982). *Cognitive Psychology*, 14: 247-279.

2. Molholm S, Ritter W, Javitt DC, Foxe JJ (2004) *Cerebral Cortex*, 14: 52–465.
3. Stein BE, Meredith MA (1993) *Merging of the senses*. Cambridge, MA: MIT Press.
4. Fujisaki W, Shimojo S, Kashino M, Nishida S (2004) *Nature Neuroscience*, 7: 773-338.
5. Harrar V, Harris LR (2008) *Experimental Brain Research*, 186: 517-524.
6. Navarra J, Hartcher-O'Brien J, Piazza E, Spence C (2009) *PNAS*, 106: 9169-917

Assessing correlates of Time Perception in EEG

Sophie K. Herbst^{1, 2}, Trevor B. Penney³, Niko A. Busch^{1,4}

¹Berlin School of Mind and Brain, ²Humboldt University Berlin, ³National University of Singapore, ⁴Charité Universitätsmedizin, Berlin

The research on time perception has gained prominence within the last decade, but the cognitive mechanisms of time perception are still a puzzle. We do not have a sensory organ that allows us to directly perceive time. Therefore, subjective durations are highly susceptible to influence by perceptual processes triggered by sensory input, such as visual or auditory stimuli. However, it is unclear which components of these perceptual processes (e.g. early automatic or later cognitive components) are crucial for duration judgments.

Our experimental approach is to present simple visual stimuli, such as flickering light. From decades of vision research, we know how these stimuli are processed on a perceptual and neuronal level. This allows us to study, which of the underlying visual processes crucially contribute to the perceived duration of the stimulus. In this project we will look at EEG-components of time perception, such as the Contingent Negative Variation (CNV), and how they reflect the subjective duration of the visual stimuli. If properties of the visual stimulus (such as flicker frequency) affect the subjective duration perception, we expect them to also influence the neural correlates of subjective duration, such as the CNV amplitude and peak latency.

In a previous study, we showed that visible flicker dilates subjective duration, which could be confirmed in the present study. Preliminary EEG-results show a variation in CNV amplitude corresponding to the variation in perceived duration induced by the flicker. Slow frequencies, which lead to the strongest dilation in perceived duration, evoke most negative CNV amplitudes. Although at this stage the findings need confirmation, they could be an important contribution to the understanding of the neural mechanisms of interval timing.

The influence of temporal delays on the perception of mass

Irene A. Kuling

MOVE Research Institute Amsterdam, Faculty of Human Movement Sciences, VU University, Amsterdam

Illusions around perceived weight are known for a quite a long time. Since the end of the nineteenth century, people study the size-weight illusion [1](more recently size-mass illusion [2]), material-weight illusion [3] and shape-weight illusion [4]. From research on time perception and adaptation to temporal delays in different sensory modalities we know that duration and temporal delays can

change perceived characteristics of a stimulus (e.g., [5, 6]). Can time also influence the perception of mass?

Recent findings in a virtual catching experiment indeed suggest an influence of temporal visual feedback on the perception of weight in an experiment in which participants had to virtually catch a ball [7]. Visual information about the falling ball gave information to estimate the Time-To-Contact, the load force of the ball was exerted by a haptic device. The researchers found that when the force exertion was preceded/delayed by 60ms, subjects perceived the weight of the ball heavier/lighter than the weight they perceived with no temporal delay between the force exertion and the contact in the display.

It is an interesting thought that temporal properties might influence quite robust characteristics as perceived weight. We want to explore this idea in more depth, using real masses. Therefore we planned an experiment in which we do a tracing task with objects of different masses and combine those with different temporal delays of the visual representation of the object. We want to test if the perceived mass changes due to the temporal delays and if, when existing, these changes could be predicted from the characteristics of the temporal delay.

[1] Murray, D. J., Ellis, R. R., Bandomir, C. A. & Ross, H. E.: Charpentier (1891) on the Size-Weight Illusion. *Perception and Psychophysics*, 61, 1681- 1685 (1999)

[2] Plaisier, M. A. & Smeets, J. B. J.: Mass is all that matters in the size-weight illusion. *PLoS ONE* 7(8): e42518. doi:10.1371/journal.pone.0042518 (2012)

[3] Wolfe, H. K.: Some effects of size on judgments of weight. *Psychological Rev.*, 5, 25-54 (1898)

[4] Kahrmanovic, M., Bergmann Tiest, W. M. & Kappers, A. M. L.: Characterization of the haptic shape-weight illusion with 3D objects. *IEEE Transactions on haptics*, 4(4), 316-320 (2011)

[5] Bloch AM (1885) Expériences sur la vision. *C R Seances Soc Biol (Paris)*, 37, 493-495

[6] Keetels, M. & Vroomen, J.: Exposure to delayed visual feedback of the hand changes motor-sensory synchrony perception. *Experimental Brain Research*, 219, 431-440 (2012)

[7] Kambara, H., Shin, D., Koike, Y.: The effect of temporal prediction error on weight perception. Poster, *Neuroscience 2012*, New Orleans, LA: Society for Neuroscience.

The Influence of Conditioned Fear on Time Perception

Jessica I. Lake, Warren H. Meck & Kevin S. LaBar

Center for Cognitive Neuroscience & Department of Psychology and Neuroscience, Duke University, Durham, NC, USA

Previous research has established that fear-inducing stimuli can distort our subjective experience of time in the range of milliseconds to seconds. Few time perception studies, however, have assessed independent measures of emotional arousal or attention in order to account for the mechanisms underlying such temporal distortions. The purpose of this study was to investigate how conditioned threat cues influence the perceived duration of a neutral stimulus presented prior to the presentation of an aversive stimulus. Participants first completed a trace conditioning experiment in which two visual cues were differentially paired with either brief aversive electrical stimulation or non-aversive tactile stimulation (50% pairing for each stimulus). A duration discrimination task was then administered during which participants decided if a comparison tone was "longer" or "shorter" in duration than a preceding standard tone. To determine the impact of conditioned fear on time perception, conditioned cues were presented in between the standard and comparison tones. Skin

conductance responses (SCRs) were recorded as the dependent measure of conditioned fear, and state-trait anxiety scores were collected as individual difference variables. Results indicated higher SCRs to the cue predicting the aversive stimulus (CS+) relative to the control cue (CS-), indicating successful fear conditioning. The duration discrimination task findings showed that comparison tone durations were underestimated on threat compared to neutral trials, suggesting that threat expectancy directs attention away from temporal processing. Additionally, the magnitude of this underestimation effect was positively correlated with trait anxiety scores. These findings demonstrate that temporal distortions can result from learned associations, potentially implicating hippocampal- and amygdala-dependent plasticity in threat-modulated time perception. The observed relationship with trait anxiety further suggests that investigation of the interaction between affect and time perception may provide further insight into the nature of anxiety and anxiety-related disorders.

Speech and gestures coordination in Autism Spectrum Disorders

Anna Lambrechts, Kielan Yarrow, Sebastian Gaigg

City University London

Abstract: Autism Spectrum Disorder (ASD) is a condition characterized mainly by impaired social interaction and communication. While its causal determinants have yet to be identified, recent research points at abnormal temporal processing as a potential source for impaired social skills (Falter et al., 2012; Allman, 2011). Individuals with ASD seem to show similar accuracy, but lesser precision than typically developing (TD) individuals (Falter et al, 2012; Allman et al, 2011; Martin et al, 2010) in time perception tasks in the sub-second to second range. On the other hand, for similar range of durations timing of communicative behaviour seems to be atypical in ASD: de Marchena and Eigsti (2010) reported a lower synchrony between speech and co-speech descriptive gestures in adolescents with ASD. In addition, they found that whereas in TD individuals, the presence of gestures improved the quality of communication as compared to speech alone, there was no such effect in the ASD group. With regards to communication perception, Silverman et al. (2010) reported that individuals with ASD were quicker than TD individuals to identify a target based on a speech-only description, but slower when provided with a speech-and-gesture description. These observations point to possible difficulties in ASD to coordinate (in production) and integrate (in perception) speech and gestures. In the present study, recordings of spontaneous speech were videotaped while participants were recalling a controlled sequence of actions that they performed in a first-aid scenario. We plan to extract the timing of acoustic and gestural signals (maxima in speech volume and pitch; onset and offset of the gestures) and examine the extent to which they are time-locked in both groups. Based on results from de Marchena and Eigsti, we predict that the time-lock between acoustic and gestural landmarks will be less strict in the ASD than in the TD group. In addition we intend to gather judgements on the quality of communication for speech-only and speech-and-gesture recordings from observers naive to the experimental design. We expect a negative correlation between the degree to which speech and gestures are locked in time and the increase in communication quality predicted between the speech-only and the speech-and-gestures condition.

Time reproduction tasks and different methods of reproduction

Giovanna Mioni & Franca Stablum

Department of General Psychology, University of Padova, Italy

Time reproduction is one of the most used methods in temporal judgments. Participants first perceive the sample duration and then are required to reproduce the duration of the stimulus previously presented. In particular are asked to produce a motor action (press a button) when they think that the duration of the reproduced stimulus is equal to the sample duration (Block, 1990). Compare to other temporal tasks (i.e. verbal estimation or time production) temporal performance with time reproduction tasks depend on high cognitive process (i.e. attention and memory) rather than differences on speed rate of the internal clock. In fact, internal clock will speed at the same rate when participants experiencing the sample duration and when participants reproducing it (Zakay, 1990; Block, Zakay, & Hancock, 1998; Rammsayer, 2001; Grondin, 2010). The attentional gate model extends the Scalar Expectancy Theory (SET) an introduced an attentional gate to explain the influence of a person's attentional resources on time perception. According to the model any reduction in attentional and working memory functions should affect temporal performance. Different methods of responding are often used in literature (i.e. pressing to end the reproduction; pressing to start and to stop the reproduction or keep pressing for the entire interval) however, the specific modality of responding is sometimes neglected; researchers most of the time only reported that participants have responded pressing a designed key on the keyboard or the space bar, assuming that all modalities are equivalent. However, preparing and executing a motor action take time and planning the execution of an action required cognitive resources. In this study we compared three different methods of reproducing the interval often employed in time reproduction task: (1) press at the end of the reproduction; (2) press to start and to stop the reproduction: and (3) keep pressing to reproduce the duration. Participants were required to reproduce six intervals ranging from 1 s to 22 s. Sixty university students took part in this study and they were randomly assigned to one of the three experimental group. Analysis of relative errors and coefficient of variation (CV) were conducted to investigate temporal performance and the difference between reproduction methods. Relative error was obtained by dividing each participant's time reproduction by the time duration of the sample interval presented for that trial. This measure provided a standard score across the different time intervals, with coefficients above and below 1.0 indicative of overproductions and underproductions, respectively. The CV is computed by taking the ratio of the standard deviation (SD) over the reproduction mean. The CV index represents the variability in temporal judgment for each participant, and evaluates the consistency of time reproductions of the same target duration. Participant were more accurate when the method of reproduction was "press to start and stop" the reproduction however the method of "keep pressing" was the one that less variable. The method of reproduction also interacts with duration indicating the method of "press to start and stop" was the best to reproduce long durations.

The temporal window of integration is influenced by the association between the audio-visual stimulus pair

Ten Oever, S., Sack, A.

Faculty of Psychology and Neuroscience, Maastricht University, Maastricht, the Netherlands

Temporal proximity is of vital importance when integrating audio-visual stimuli. Only within certain delays between the stimulus pair will multisensory neurons respond (Wallace, Wilkinson et al. 1996) and will behavior be influenced (Spence and Squire 2003). However, this temporal window of integration (TWOI) does not seem to be constant and is influenced by the type of stimuli. In the current proposed research we would like to investigate how associations between stimulus pairs influence the time in which stimuli will still be integrated. We presented a stream of audiovisual stimulus pairs in which in half of the blocks there is a clear relationship between pitch and color. In the other half of the blocks there is no apparent relationship. Participants had to respond to primed stimuli and indicate whether the auditory stimulus had a high or low pitch. We expect that associated stimuli will produce lower reaction times than unrelated stimuli. Additionally, we manipulated the stimulus onset asynchronies of the primed stimulus pairs and expected that the lowered reaction times are apparent at wider stimulus onset asynchronies. These results would indicate that the association between the content of the stimuli influences the temporal properties in which the stimuli are still integrated and these temporal properties can be changed online and rapidly dependent on the current association of the audiovisual stimuli.

References:

Spence, C. and S. Squire (2003). "Multisensory integration: maintaining the perception of synchrony." *Current Biology* 13(13): R519-R521.

Wallace, M., L. Wilkinson, et al. (1996). "Representation and integration of multiple sensory inputs in primate superior colliculus." *Journal of Neurophysiology* 76(2): 1246-1266.

How strongly can we connect: A feedback loop of synchrony, similarity and empathy

Tal-Chen Rabinowitch & Ariel Knafo

Department of Psychology, Hebrew University of Jerusalem, Israel

Synchronization, and specifically rhythmic synchrony, appears to be a fundamental strategy and a cognitive capacity required by interacting humans for the successful performance of many time-dependent joint tasks. At the same time, synchronization may also contribute to enhancing the connection between individuals, making them feel more similar and more empathic one towards the other. I hypothesize that such an enhanced sense of similarity and empathy, induced during synchronous interactions, may further improve the level of rhythmic synchrony between interacting individuals, introducing a reinforcing positive feedback loop. My goal is to directly study the bi-directional links between similarity and synchrony and between empathy and synchrony in primary school children, who are in the process of developing their social skills. This will help determine whether and to what extent such links exist, and provide a test for the feedback loop hypothesis.

Spontaneous behavioral variability-characterization of neural circuits

Sathish K Raja, Bjoern Brembs

Institute fur Neurobiologie, FU-Berlin, 10178 Berlin, Germany

Most of the brain regions are spontaneously active even without the absence of external stimuli. Spontaneous turning attempts (yaw torque) initiated by fruit flies tethered at the torque meter, are not completely governed by random noise in the brain but generated and controlled by intrinsic

circuits (Maye et al. 2007). This conclusion is based, among other analyses, on nonlinear forecasting analyses (S-Map procedure) detecting a nonlinear signature in the temporal structure of the torque data. However, very little is known about the underlying circuits and the neurobiological mechanisms for generating spontaneous actions.

We used the Gal4/UAS system to silence candidate neural circuits in the fly brain, by expressing tetanus toxin light chain (TNT-E) to prevent synaptic vesicle fusion. Yaw turning behavior of tethered flies was recorded with the wing-beat analyzer; the environment of the fly was kept spatially homogeneous and temporally constant, preventing the fly from perceiving any stimuli, which might elicit turning behavior. Candidate lines expressing mainly in the central complex and mushroom-bodies were measured. S-Map analysis suggests a defined subset of central complex neurons to be involved in generating spontaneous behavior, while the mushroom-bodies seem not to play any role.

Transgenic lines expressed in ellipsoid body regions show normal walking activity in the Buridan paradigms that indicate general architecture of the walking is not affected. Automated detection of yaw torque spikes (the equivalent of body-saccades in free flight) did not reveal any significant difference from control strains in the affected candidate lines, suggesting that the general behavioral repertoire of turning behavior is also unaffected by the TNT-E expression.

I will present detailed characterization on the interesting lines along with tools to study temporal variability.

Audiovisual Synchrony Perception in adults with Autism Spectrum Disorders

Paula Regener¹, Scott Love², Karin Petrini³, & Frank Pollick¹

¹School of Psychology, University of Glasgow, ²Department of Psychological & Brain Sciences, Indiana University, ³Institute of Ophthalmology, University College London

The ability to integrate synchronous auditory and visual information is a crucial part of everyday life. Studies show that individuals with Autism Spectrum Disorder (ASD) have problems to integrate auditory and visual information such as in the McGurk illusion. However, this is less obvious when a temporal aspect is added to audiovisual integration such as in audiovisual synchrony perception. In the current study 16 adult males with ASD and their age, sex and IQ matched controls were shown a range of audiovisual displays (short clips of beeps and flashes, human motion and speech). Within the audiovisual displays the degree of audiovisual asynchrony was manipulated, i.e., the auditory information was presented 333, 267, 200, 133 and 67 ms before or after the visual information. For each type of audiovisual display the participants were asked to make a temporal order and a synchrony judgement. The results will reveal whether the point of subjective synchrony and the temporal integration window are different for adults with ASD compared to controls, and whether these differences depend on the type of audiovisual display or type of judgement (temporal order or synchrony).

Time after time: Repeated stimuli create temporal expectations.

Darren Rhodes, Massimiliano Di Luca
School of Psychology, University of Birmingham

We will present a series of experiments investigating the effect of repeated stimulus presentation (either sounds or lights) on perceived timing of a subsequent stimulus. At the beginning of each trial, a series of sounds or lights is presented with a constant isochronous interval. One final stimulus is presented either rhythmically or with a temporal deviation from isochrony. Several psychophysical tasks have been used: (1) participants judged whether the sequence of stimuli is isochronous or not, (2) participants judged whether the last stimulus in the sequence is presented before or after a temporal probe in another modality, (3) participants judged whether the last stimulus and the probe are synchronous/asynchronous. Results indicate that isochronous sequences affect the perceived timing of stimuli so that deviations from regular rhythm tend to be perceptually minimised. Such type of effect is explained as a modulation of prior entry effects based on the expectations on when a stimulus should appear. The expectation can be modelled in a Bayesian framework as the combined influence of the sensory "likelihood" with a "prior" expectation built on the regular presentation of the previous stimuli.

Sensorimotor synchronization to auditory and visual cues in ageing and Parkinson's disease

Eugenie Roudaia, Jonathan Gallego, Hugh Nolan, Conor Fearon, Fiona Newell, Richard Reilly
Trinity Centre for Bioengineering
Trinity College Institute of Neuroscience, Trinity College Dublin, Ireland

Parkinson's disease is associated with abnormalities in gait, reduction in automaticity of movement, and deficits in temporal processing. Some persons with PD experience freezing of gait (FoG), a temporary interruption in gait and an inability to continue walking. The causes of this impairment are largely unknown. Although PD patients with FOG synchronize repetitive bilateral upper-limb movements with an auditory metronome as well as age-matched controls, they show greater variability than controls when required to continue the rhythmic movements in the absence of external cues (Vercruyse et al., 2012). Synchronizing walking to rhythmic auditory or visual cues can reduce freezing, and a step-training program incorporating rhythmic auditory stimulation improved functional gait in persons with FoG (Kadivar et al., 2011). The mechanisms underlying these benefits are unknown. The goal of this project is to examine how training on sensorimotor synchronization can improve internal generation of rhythmic movement and whether the type of sensory stimulation provided influences performance.

In this study, we will examine bipedal rhythmic movements in younger adults, healthy older adults, and persons with Parkinson's disease, with and without FoG, while they are required to synchronize bipedal movements with rhythmic stimulation and to continue the same movements in the absence of external cues. Multisensory presentation of rhythmic cues improves sensorimotor synchronization in younger and older adults (Elliott et al., 2011). However, it is unknown whether Parkinson's disease affects multisensory integration of timing cues. We will compare the effects of auditory, visual, and audiovisual cues on performance to determine whether multisensory presentation of rhythmic cues benefits performance. We will also compare metronome and musical

cues, as synchronization to music may provide an additional benefit over metronome beats (Styns et al., 2007). We will also record EEG during these synchronization/continuation tasks to examine differences in neural correlates of rhythmic movement in healthy aging and Parkinson's disease.

1. Elliott, M.T., Wing, A.M. & Welchman, A.E., 2011. The effect of ageing on multisensory integration for the control of movement timing. *Experimental brain research*. 213(2-3), pp.291–8.
2. Kadivar, Z. et al., 2011. Effect of Step Training and Rhythmic Auditory Stimulation on Functional Performance in Parkinson Patients. *Neurorehabilitation and neural repair*, 25(7), pp.626–635.
3. Styns, F. et al., 2007. Walking on music. *Human movement science*, 26(5), pp.769–85.
4. Vercruyse, S. et al., 2012. Abnormalities and cue dependence of rhythmical upper-limb movements in Parkinson patients with freezing of gait. *Neurorehabilitation and neural repair*, 26(6), pp.636–45

The effect of temporal frequency induced duration compression and speed adaptation on the flash-lag illusion

Edward Rowland & Szonya Durant

Psychology dept. Royal Holloway, University of London, UK.

Evidence shows 20Hz temporal frequency adaptation to an area of the visual field compresses perceived duration of further events in that area, suggesting the existence of a separate mechanism for computing durations (Johnston, Arnold, & Nishida, 2006). The functional purpose of this mechanism is not clear, attempts to link duration compression to action have proved unfruitful (Marinovic & Arnold, 2012) so the question remains. There is the possibility that duration compression has an effect on other visual processes. Examining the effect of duration compression on the flash lag illusion (Nijhawan, 1994) may provide clues to visual function for the duration mechanism. The illusion occurs when an observer perceives the position of a moving object to be further along its trajectory relative to the position of a spatially localized flash; crucially the size of this positional offset scales with object speed, therefore it has a fixed time component. If 20Hz temporal frequency adaptation changes this time component, this implies a function for the visual duration mechanism in visual motion prediction and positional computations; this is what we test in the study. Using a flickering square wave grating with a temporal frequency of 5Hz or 20Hz as the adapting stimulus and a control condition with no adaptation we measure the change cause by adaptation in the flash-lag effect using a moving bar with a speed of either 18.2 & 27.3 degrees/second, giving two speed conditions. By varying the displacement of the flash relative to the bar position, participants were asked to judge whether the bar was to the left or right of the flash. We constructed a psychometric function from the responses taking the 50% point as the point of subjective equality where bar and flash are perceived to be aligned. 5Hz temporal frequency adaptation has no clear, consistent effect. However, 20Hz adaptation consistently appears to reduce the magnitude of the flash-lag effect across both speeds. I will discuss these findings in the context of temporal frequency adaptation's effect on perceived bar speed and the implications of this finding with respect to the potential function of duration compression in perception of motion and relative position.

Johnston, A., Arnold, D. H., & Nishida, S. (2006). Spatially Localised Distortions of Event Time. *Current Biology*(16), 472–479.

Marinovic, W., & Arnold, D. H. (2012). Separable temporal metrics for time perception and anticipatory actions. [Article]. *Proceedings of the Royal Society B-Biological Sciences*, 279(1730), 854-859. doi: 10.1098/rspb.2011.1598

Nijhawan, R. (1994). Motion extrapolation in catching. [10.1038/370256b0]. *Nature*, 370(6487), 256-257.

Time Perception in Developmental Disorders: Asperger's Syndrome

Susanna Salomäki^{1,3}, Jarno Tuominen¹, Valtteri Arstila¹, Valdas Noreika¹, Christine Falter², Annika Härmälä³

¹ University of Turku, ² University of Groningen, ³ Turku University Hospital

Children with Asperger's syndrome (AS) are usually poor at perceiving time, which makes it difficult for them to manage timing in everyday life. Despite the fact that people working with AS children agree that these problems exist, little is known about the specific mechanisms underlying time processing in AS and other developmental disorders. The aim of this study is to find out 1) whether there is a difference in time processing tasks between children with AS and children developing typically and 2) whether their attention explains the results. The participants will be 30 children with AS and 30 typically developing controls age between 8 and 14 years. Children who meet the AS criteria of ICD-10 and DSM-IV at the time of research and who do not have other neurological or psychiatric diagnoses or major deficits in motor, visual or auditory skills will be included in the AS-group. The participants will be matched group-wise on age, gender, IQ and maternal education. Time processing will be assessed with 1) a visual simultaneity task, which assesses the temporal threshold for perceiving two sequential events as simultaneous, 2) an auditory duration discrimination task, which assesses, how precisely the participants detect a sound with different duration from three stimuli on sub-second and supra-second level, 3) a motor tapping task with left and right hand, which assesses the speed chosen freely and the consistency of rhythm on self-produced motor activity, 4) the durations of events tasks, which assesses, how precisely the participants can estimate the durations of natural events on their research visit, 5) the participants' insight to their own time processing tasks, where the participants are asked to tell how they felt about the tasks and how they describe their performance and 6) "It's about time"-questionnaire to the parents, which assesses how the parents see the participant's temporal processing in everyday life. Attention will be studied on Conners' Continuous Performance Test II, which is a computerized assessment of neuropsychological functioning on attention disorder. Preliminary results from the pilot study will be reported in a student poster session.

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

Maren Schmidt-Kassow, Linda Heinemann, Cornelius Abel, Jochen Kaiser
Institute of Medical Psychology, Goethe University, Frankfurt am Main, Germany

Temporal predictability of auditory events induces larger P300 amplitudes and shorter P300 latencies compared to stimulus presentation with variable onset asynchronies. This suggests that

periodic stimuli lead to neuronal entrainment resulting in 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 stimulus encoding by the use of event-related potentials. 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 exercising 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, P300 amplitude, and behavioral performance should vary as a function of motor variability. Cycling variability was expected to correlate positively with both P300 latency and P300 amplitude and negatively with behavioral performance.

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 positively with both P300 latency and error rate. These findings indicate that auditory-motor synchronization enhances the attentional processing of periodical auditory stimuli.

Predicting Adjustments in Response Caution from Feedback-Based Theta-Band Activity on a Trail-to-Trial Basis

Sabine Scholz, Udo Böhm, & Hedderik van Rijn

University of Groningen, Dept. of Experimental Psychology, Groningen, The Netherlands

In speeded decision-making tasks, a trade-off between speed and accuracy takes place. This trade-off can be expressed by the level of response caution. It has been shown that response caution can be strategically adjusted depending on whether the emphasis lies on speed or accuracy. It has further been found that the amplitude of the contingent negative variation (CNV) predicts the level of response caution on a trial-to-trial basis. It has also been shown that response caution is not only influenced by explicit speed or accuracy cues, but also by feedback on the performance on the previous trial. More specifically, when negative feedback is given on the timing of the response ('too late'), response caution will decrease on the next trial. In contrast, when negative feedback is given on accuracy ('incorrect'), response caution will increase. As feedback processing is reflected in theta-band activity, we will investigate whether theta-band activity and type of feedback predict the level of response caution adjustment and the amplitude of the CNV on the subsequent trial. This study will shed additional light on the role of the CNV in human decisionmaking, based on the assumption that the CNV reflects general preparatory processes instead of the state of the temporal accumulator.

Cross-modal N100 suppression: Effects of attentional orienting

Ellen Schüßler¹, Erich Schröger², Franziska Knolle¹ & Sonja A. Kotz¹

¹ *Max Planck Institute for Human Cognitive and Brain Sciences*

² *University of Leipzig*

Forward predictions are not only crucial to predict somatosensory consequences of movements, but may also mimic cross-modal sensory consequences. When a visual stimulus precedes an auditory stimulus in a temporally predictable fashion, this temporal regularity leads to an amplitude suppression of the auditory N100 event-related brain response (ERP) when compared to an unpredictable tone. In addition, previous research has shown that a contingent negative variation (CNV) develops between two consecutive stimuli. This has been linked to the anticipation of a stimulus or the interval timing between two stimuli. In our planned study we investigate whether the auditory N100 suppression effect is modulated by attention and if attentional allocation affects predictive processing during the inter-stimulus-interval. We use a visual-to-auditory prediction paradigm and manipulate the predictability of the temporal structure (regular vs. random) and the formal identity of a tone (standard vs. deviant). In one session participants passively perceive only standard tones (680 Hz, 100%) and in a separate session frequent standard (680 Hz, 80%) and infrequent deviant tones (760 Hz, 20%). We hypothesize that the amplitude of the auditory N100 is modulated as a function of stimulus predictability, comparing the ERPs of a temporally predictable and unpredictable tone separately in the two sessions. In the case of standard tones only we expect an N100 suppression effect for temporally predictable compared to unpredictable tones. Contrastively, when the formal identity of a tone is less predictable, attention may be focused more directly onto temporally predictable tones. Given that attention is known to elicit negative deflections in this time range this should lead to a reduced or even reversed N100 suppression effect. Additionally, if attention affects predictive processing, the CNV should be larger prior to temporally predictable than unpredictable tones.

Synchronization and continuation during a dance act

Helena Sgouramani¹, Chris Muller², Leon van Noorden², Marc Leman², & 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*

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 (e.g., Repp, 2005).

In such a framework, the role of many different parameters has been assessed. The modality (e.g., Elliott, Wing, & Welchman, 2010), and the physical properties of the external pacer (e.g., Hove, Spivey, & Krumhansl, 2010; Ruspantini, D'Ausilio, Maki, & Ilmoniemi, 2011) seem to modulate sensorimotor performance, thus it seems pertinent to further investigate the nature of the pacer. Moreover, acquired knowledge/training has been proposed as an influential factor in studies comparing the performance of experts versus naïve participants (e.g., Krause, Pollock, & Schnitzer, 2010; Miura, Kudo, Ohtsuki, & Kanehisa, 2011). Additionally, the actual movement involved in a given task modulates synchronization patterns, thus the characteristics of the movement itself may be important to such tasks (e.g., Rodger & Craig, 2011).

In our study, we aimed to investigate, for the first time, the synchronization-continuation paradigm in a more naturalistic and embodied experimental set up. Specifically, we utilized whole-

body audiovisual dance stimuli in normal, blurred (degraded body reference), and abstract (no body reference) conditions, in order to clarify the role of the metronome's attributes in the participants' performance. Participants had to synchronize with the external pacer by performing the step required for 10 times (synchronization phase) followed by a continuation phase for 11 more executions while keeping the spatial and time attributes of the step and the in between intervals unaltered. A simple dance step as required movement further allowed the examination of task differences from the, not very naturalistic, finger-tapping tasks. In addition, measurement of participant movement via a motion capture system allowed the collection of data at a millisecond level of accuracy. Finally, experimentation utilizing dancers versus naives participants allowed us to investigate the possible differences due to experience/training, extending the findings of previous studies with musicians.

References

- Elliott, M. T., Wing, A.M., & Welchman, A.E. (2010). Multisensory cues improve sensorimotor synchronization. *European Journal of Neuroscience*, 31, 1828-1835.
- Hove, M. J., Spivey, M., & Krumhansl, C. L. (2010). Compatibility of motion facilitates visuomotor synchronization. *Journal of Experimental Psychology: Human Perception and Performance*, 36, 1525-1534.
- 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.
- 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.
- Repp, B. (2005). Sensorimotor synchronization: A review of the tapping literature. *Psychonomic Bulletin & Review*, 12(6), 969-992.
- 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.
- 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.

The metabolic substrates of visual duration discrimination

Devin Blair Terhune, Sonia Russo, & Roi Cohen Kadosh

Department of Experimental Psychology, University of Oxford, South Parks Road, Oxford

Neurochemical concentrations in primary visual cortex may contribute to variability in the discrimination of visual durations. Here we investigated the metabolic substrates of visual duration discrimination using magnetic resonance spectroscopy (MRS), a technique used to estimate the concentration of brain metabolites in a particular brain voxel. Healthy controls completed a visual duration discrimination task in which they made shorter/longer judgments for the durations of a series of centrally-presented circles in reference to the duration of a standard circle. Performance is computed using the point of subjective estimation (PSE) based on the fit of a psychometric function to individual participants' data. Independently, participants underwent MRS in which GABA, glutamate, and creatine concentrations in M1 and V1 were estimated. We expect PSEs to be associated with variation in V1 metabolite concentrations, in particular, GABA and glutamate, but

not M₁ concentrations. Data collection for this study has recently been completed and the results will be presented at the workshop.

Spectro-temporal unfolding of temporal orienting of attention

Danai Theodosopoulou, Mariagrazia Capizzi, Daniel Sanabria, & Angel Correa
Departamento de Psicología Experimental, Universidad de Granada

All behaviors unfold over time; therefore, our ability to perceive and adapt our behavior according to the temporal constraints of our environment is likely a fundamental requirement for successful behavior (Nobre et al., 2007).

Temporal preparation has been defined as our ability to anticipate and prepare an optimal response to forthcoming events in our environment (Nobre et al., 2007). Temporal preparation requires integration of different types of temporal information. First, information provided by temporal predictions i.e., temporal orienting. Second, information provided by the duration of the previous temporal events, the sequential effects (Cappizi et al., 2012). One main question is whether temporal preparation involves controlled or automatic processing. To address this question temporal orienting and sequential effects need to be measured under conditions of limited resources. One such exploration is offered in a previous study by Cappizi et al. (2012).

Cappizi et al. (2012) used a secondary demanding task and showed that temporal orienting effects were significantly reduced by performing a concurrent working memory task while the sequential effects were preserved (Cappizi et al., 2012). Subsequently they recorded event related potentials (ERP's) in the same experimental conditions in order to investigate how the behavioral dissociation would be expressed in neural activity measures (Cappizi et al., 2012, in press).

Previous studies (Rohenkohl et al., 2011; Cravo et al., 2011) have investigated oscillatory brain activity and how it modulates over the time intervals which target events are expected. Specifically, increased low frequency power has been documented (< 30 Hz) following the time course of predictable time intervals.

In the poster I will present a project proposal for the spectral analysis of the EEG recordings from Cappizi's dual-task study (Cappizi et al., 2012, in press). We are interested in the spectro-temporal unfolding of both temporal orienting and sequential effects during the preparatory interval (foreperiod). Time/frequency analyses will focus on epochs locked to the cue onset and will compare EEG activity related to early vs. late temporal expectations (temporal orienting) and between EEG related to previous short vs. previous long foreperiods.

Literature

Capizzi, M., Correa, A., & Sanabria, D. (2012, in press). Temporal orienting of attention is interfered by concurrent working memory updating. *Neuropsychologia*

Cappizi M. Sanabria D. & Correa A. (2012) Dissociating controlled from automatic processing in temporal preparation. *Cognition* Vol.123: 293-302

Nobre A. C., Correa A. & Coull J.T. (2007) The hazard of time. *Current Opinion in Neurobiology*, 17:1-6

Rohenkohl G. & Nobre Anna C. (2011) Alpha Oscillations Related to Anticipatory Attention Follow Temporal Expectations. *The Journal of Neuroscience*, 31(40): 14076-14084

Cravo A. M., Rohenkohl G., Wyart V. & Nobre A.C. (2011) Endogenous modulation of low frequency oscillations by temporal expectations. *J. Neurophysiol* V.106: 2964–2972

Predictable visual stimuli are perceived earlier than unpredictable events

Barbara Wirxel

Universitätsklinik Tübingen/ Hertie Institute for clinical brain research, Dept. of cognitive neurology, DE

How is it possible that we timely react to visual events despite the significant processing delays within the visual system? This delay is estimated to be already about 100ms in higher visual areas, a delay which is relevant if one needs to initiate fast reactions, such as catching a ball in flight or initiating escape. To compensate such delays the sensorimotor system employs predictive mechanisms. Yet, it is currently unclear whether delay compensation already occurs on a strictly perceptual level. Hence, we tested whether predictability of a visual stimulus affects the time of perceived stimulus onset. Specifically, we hypothesized that predictable visual stimuli have an earlier perceived onset compared to non-predictable stimuli.

We tested our hypothesis in a psychophysical experiment, in which we initially screened 34 subjects in a dual task that engaged temporal interval judgements. In the middle of a black screen streams of individual letters were presented. Each letter was presented for 300ms with a 1000ms default interval between letters. The sequence of letters was either in alphabetic order and thus predictable or, alternatively, the last letter of a sequence was chosen at random and thus not predictable. In each trial subjects had to indicate whether or not the last letter agreed with the alphabetic order. Moreover, subjects had to estimate whether the duration of the last interval, which was of varying length, was either longer or shorter as compared to the preceding intervals of 1000ms duration. Varying the length of the last interval allowed us to estimate the point of subjective equivalence (PSE) between intervals. As we expected predictable letters to be perceived earlier, the PSE should be larger in predictable sequences than the PSE in non-predictable ones. Since our experiment required precise timing we applied rather strict exclusion criteria to both trials and subjects. For the 10 subjects that survived these criteria there was a significant shift of the PSE towards larger values for predictable sequences (median shift: 33.3 ms; $p=0.043$). Hence, our findings show that predictable visual stimuli are in fact perceived earlier than non-predictable ones. This suggests that even the perceptual system is compensating for delays in sensory information processing, allowing us to establish a timely percept of our environment.

Zolpidem Increases Subjective Sleep Time Estimations in Daytime Naps

Kelly M. Rowe¹, Elizabeth A. McDevitt¹, Nicola Cellini², Katherine A. Duggan¹, Ashley A. Ricker¹, Sara C. Mednick¹

*¹Department of Psychology, University of California, Riverside, CA;
²Department of General Psychology, University of Padua, Padua, Italy*

Introduction: Changes in context, physiology and environment can alter time perception during wake. We examined the effect of zolpidem on time perception during sleep and correlated sleep features (wake after sleep onset (WASO), sleep latency and total sleep time (TST)) with subjective sleep time (SST) estimations. We asked: 1) What is the effect of zolpidem on SST? and 2) Which features of sleep are associated with SST?

Methods: 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 and SST was reported on a post-nap questionnaire. We evaluated SST estimations in minutes (Ts) and the difference between SST and TST (Td), where a positive score indicated an overestimation of sleep time. We analyzed drug effects using a repeated-measures ANOVA on the following variables: Ts, Td, WASO, sleep latency, and TST. Correlations between SST, and the aforementioned sleep features were evaluated.

Results: Both zolpidem groups showed longer Ts compared to placebo (5mg: $p=.03$; 10m: $p=.005$). Td indicated TST was underestimated more in the placebo condition compared with zolpidem (5mg $p=.100$ and 10m $p=.003$). WASO was negatively correlated with Ts in all three drug conditions (placebo ($r=-.729$, $p=.001$), zolpidem 5mg ($r=-.826$, $p=.000$) and zolpidem 10mg ($r=-.635$, $p=.005$)). Zolpidem (10 mg) also showed significantly higher WASO ($p<.006$) compared to placebo. No significant differences in TST or sleep latency were observed.

Conclusion: A pharmacological intervention produced longer sleep time estimations in zolpidem compared to placebo. Sleep time biases were negatively correlated with WASO within each condition, suggesting that zolpidem may increase subjective sleep time by decreasing minutes of WASO.