ISCH Action TD0904
Time In MEntaL activitY: theoretical, behavioral, bioimaging and clinical perspectives (TIMELY)

# TIMELY Workshop on "Temporal Prediction" Granada (SP), 18 October 2013

Organized by Ángel Correa, Daniel Sanabria, Mariagrazia Capizzi, and Argiro Vatakis

## Information, Programme, Activities, & Abstracts

**Location:** Sala de conferencias complejo administrativo triunfo. Address: Avda. del Hospicio SN, 18071 Granada.
Google map:
https://maps.google.es/maps/ms?msid=207057080819791336777.0004d999ed737981ed506&msa=0&iwloc=0004d999f10856c1c027d

**Travelling by air**: Granada airport (20 km from Granada) is well connected to Madrid. Otherwise, you can get to Granada from Malaga airport. You can then travel from Malaga city to Granada by bus (more information at: www.alsa.es). The journey time is of about 1,5 hours.

**Participation:** Free. Registration is required due to limited space. To register visit this link http://doodle.com/t9w6c2ng3z3ue28a and enter your name and email. Argiro Vatakis will email you verifying your registration for the event.

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

## October 18th, 2013

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| 9:30 | Coffee & Welcome |
| 10:00 – 10:50 | **The brain engaged in rhythm prediction**<br>By Ricarda Schubotz |
| 10:50 – 11:40 | **fMRI reveals distinct neuroanatomical substrates for generating and updating temporal expectations**<br>By Jennifer Coull |
| 11:40 – 12:30 | **Mapping temporal preparation.**<br>**Theoretical and clinical implications**<br>By Monica Triviño |
| 12:30 – 13:30 | *Lunch break (on your own)* |
| 13:30 – 14:20 | **How the sensory brain keeps track of time**<br>By Domenica Bueti |
| 14:20 – 15:10 | **Time-course analysis of temporal preparation on central processes**<br>By Rolf Ulrich |
| 15:10 – 16:00 | **Contextual effects in event-timing result from optimal encoding strategies**<br>By David Burr |
| 16:00 – 16:30 | *Coffee break* |
| 16:30 – 17:20 | **Timing and prediction in perception and action-perception coupling**<br>By Sonja A. Kotz |
| 17:20 – 18:10 | **Title of talk**<br>By Anna Christina Nobre |
| 20:00 | *Workshop-end Dinner* |

# Abstracts

**The brain engaged in rhythm prediction**
**Ricarda Schubotz**
*University of Münster, Germany*

Ventral premotor cortex has been proposed to provide a common platform for timing, both perceived and produced. In fact, the ability to accurately time movements on the basis of auditory input is essential in a variety of domains and situations, such as speech, singing and synchronizing to music, but also in environments with missing or only scarce visual information. It also shows that ventral premotor cortex is engaged in processing of visual rhythms. Several studies are presented that explore these rhythmic functions of premotor cortex. By means of fMRI, rhythmic predictions were compared to other types of prediction such as object-based and spatial predictions. Off-line rTMS and fMRI are combined to uncover the role of ventral premotor sites in feed-forward computations enabling accurate auditory-motor timing. Moreover, fMRI was used to determine whether the musical rhythms that are subjectively judged as beautiful boost activity in motor-related areas and if so, whether this effect is driven by preferred tempo, the underlying pulse people tune in to. Finally, we explored whether rTMS over the left ventral premotor cortex affects individual tempo preference strength.

**fMRI reveals distinct neuroanatomical substrates for generating and updating temporal expectations**
**Jennifer Coull**
*Laboratoire des Neurosciences Cognitives, Aix-Marseille University, France*

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

**Mapping temporal preparation.**
**Theoretical and clinical implications**
**Monica Triviño**
*Hospital San Rafael, Granada, Spain*

Temporal preparation is a cognitive function relatively unexplored in the clinical setting. However, deficits in temporal preparation have been associated with brain damage and their consequences can include impaired motor coordination, impulsiveness or intolerance to delay. Define the structures and circuits involved in the two main mechanisms of temporal preparation described in the literature (Correa et al., 2006) —that is, controlled (temporal orienting and foreperiod effect) vs. automatic temporal preparation (sequential effects)— will improve our characterization of specific patients' profiles defining their associated deficits in basic timing functions and proposing new rehabilitation programs. Firstly, we present a study where a multiple regression analysis was performed to measure the relationship between the lesion size in specific brain areas of a group of patients and their behavioral reaction time performance in a temporal preparation task, as measured by the three effects mentioned above. The main finding was that each temporal preparation effect was related to a differentiated neural network. Specifically, the controlled temporal preparation effects were related to different prefrontal and temporal areas, while the automatic effects were related mainly to subcortical structures.
These results are interesting from both a theoretical and clinical point of view. If patients with prefrontal lesion showing impulsiveness and intolerance to delay have deficits in controlled temporal preparation processes, could they benefit from the more automatic mechanisms dependent on subcortical structures and supposedly preserved? Secondly and to test this hypothesis, we present a preliminary study where two prefrontal patients performed a rhythm synchronization training during three weeks. The results showed that both patients improve not only their ability to produce a rhythmic motor response and prepare better in time, but also this improvement was transferred to their temporal perception ability and, more important, their impulsivity and the intolerance to delay was also reduced.

**How the sensory brain keeps track of time**

**Domenica Bueti**
*Department of Clinical Neurosciences, University Hospital of Lausanne, Switzerland*

Time is embedded in any sensory experience: the movements of a dance, the rhythm of a piece of music, the words of a speaker are all examples of temporally structured sensory events. In humans, if and how sensory cortices perform temporal processing remains unclear. In my talk I will present a series of magnetic stimulation and MRI studies in which I highlight the contribution and the temporal dynamics visual and auditory cortices in the processing of time in the millisecond-second range. By showing the involvement of 'amodal' as well as modality specific sensory cortices in temporal computations, my work supports the existence of distributed temporal mechanisms.

**Time-course analysis of temporal preparation on central processes**

**Rolf Ulrich**
*Department of Psychology, University of Tübingen, Tübingen, Germany.*

Participants usually respond faster to a response signal when this signal is preceded by a warning stimulus than when it is not. A question of theoretical importance is the locus of this facilitating effect within the information processing stream. Los and Schut (Cogn Psychol 57:20–55, 2008) suggested that temporal preparation acts on central processes while perception of the response signal is under way. The present study provides a stochastic model (central preparation model)

based on this hypothesis and presents three experiments testing this model.

**Contextual effects in event-timing result from optimal encoding strategies**

**David Burr**
*University of Florence, Italy*

The perception of event duration is highly susceptible to contextual effects. An irrelevant *distractor* interval immediately before a test interval causes the test to appear shorter; and vice versa. This effect occurs only for brief base intervals, less than 500 ms or so. Similarly, reproduction of time intervals depends critically on the context, tending towards the mean duration of the particular experimental session. The degree to which both of these effects occur depends crucially on the precision of temporal discriminations of observers. The results were well fit by a simple Bayesian model that combines noisy estimates of duration with appropriate *priors*. The modelling suggests that far from reflecting aberrant behaviour, the context effects are actually statistically optimal, serving to minimize error. These results highlight the efficiency and flexibility of sensori-motor mechanisms that estimate temporal duration.

**Timing and prediction in perception and action-perception coupling**

**Sonja A. Kotz[1, 2]**
[1]*MPI for Human Cognitive and Brain Sciences, Leipzig, Germany*
[2]*University of Manchester, School of Psychological Sciences, UK*

To detect and adapt to dynamic changes in the environment, we need to trace the temporal structure of sensory, multisensory, and sensorimotor events. For example, while sound duration in audition is considered as an inherent property of sounds, regularity and order of perceived acoustic events define contextually extracted, statistically sampled temporal relations among sounds. These relations constitute the backbone of prediction in audition, determining both "when" an event is likely to occur (regularity), and "what" type of event can be expected at a given point in time (order) and should, in principle, be extendable to the multisensory and sensorimotor domains. In line with these assumptions, I will present a novel cortico-subcortical neurofunctional model of temporal processing that involves the division of labor between the cerebellum and the basal ganglia in the predictive tracing of sensory (i.e. auditory), multisensory, and sensorimotor events. Specifically, the cerebellum and its associated thalamo-cortical network appear to play a role in pre-attentive encoding of event-based temporal structure, while the attention-dependent basal ganglia-thalamo-frontal system is involved in reanalysis and re-sequencing of potentially incongruent or unexpected temporal structure of a stimulus (prediction error). I will discuss recent human electrophysiological and fMRI data consistent with this a model.