Fédération 3C
COMPORTEMENT - CERVEAU - COGNITION

Perspectives on temporal cognition

2 June 2022 - Marseille

timecog.sciencesconf.org

ILCB
Institute of language, communication and the brain

Laboratoire de Psychologie Cognitive

Laboratoire de Neurosciences Cognitives

Table of contents

GENERAL TIMETABLE

9h – 9h30. Welcome coffee and opening words.

9h30 – 10h30. **Keynote**. The study of time in psychology: historical perspective. *Sylvie Droit-Volet.*

10h30 – 11h. Coffee break.

11h – 11h30. **Short talk**. Lost in time: rethinking duration estimation outside the brain. *David Robbe.*

11h30 – 12h. **Short talk**. The costs and benefits of temporal predictability. *Jennifer Coull.*

12h – 12h30. **Short talk**. Motor contribution to auditory temporal predictions. *Benjamin Morillon.*

12h30 – 14h. Lunch.

14h – 15h. **Keynote**. The topographic representation of time in human brain. *Domenica Bueti.*

15h – 15h30. Coffee break.

15h30 – 16h30. **Poster session**.

16h30 – 17h30. **Keynote**. How movements shape the perception of time. *Martin Wiener.*

17h30 – 19h. Closing words and buffet.

ORAL PRESENTATIONS ABSTRACTS

9h30 – 10h30. Keynote. The study of time in psychology: historical perspective. *Sylvie Droit-Volet.*

11h – 11h30. Short talk. Lost in time: rethinking duration estimation outside the brain. *David Robbe.*

A long-standing paradigm in cognitive neuroscience considers time as information and assumes that humans and animals directly estimate the duration of intervals in the sub and supra second ranges internally, through the activity of distributed neuronal ensembles serving the function of population clocks. In this framework, time and space are similar dimensions of behavior (both can be segmented into repetitive units) and changes in the dynamics of population clocks explain why the perception of time can suffer significant distortions. During my presentation, I will start by challenging this paradigm from the angle of Bergson's proposal that the perception of time is unlike space because it is ever-changing and indivisible (2 successive seconds are not experienced equivalently). Consequently, measuring such an heterogeneous perception can not be achieved directly or purely internally but requires taking advantage of concurrent objective changes in the environment (e.g., an observed or self-generated movement; the variation of a sensory stimuli) whose magnitude will be read out when a time interval ends. In a second step, I will present behavioral evidence in support of such a mechanistic proposal.

I will conclude by proposing that time should be considered as a force rather than an information and that living beings, although they are sensitive to time, cannot directly measure its passage internally, which they compensate through interactions with regularities afforded by the world and representation drawn from movements in space.

11h30 – 12h. Short talk. The costs and benefits of temporal predictability. *Jennifer Coull.*

Being able to predict when relevant events are likely to occur allows us to orient attentional resources to those specific moments in time. Such temporal orienting allows any event occurring within this temporal focus to be processed more quickly and more accurately. Yet the temporal predictability of events can sometimes induce maladaptive, impulsive modes of behaviour, due to a failure in motor inhibition. In addition, any breach in the usual temporal predictability of sensory events are particularly disruptive for individuals with schizophrenia, perhaps reflecting a selective temporal perturbation in this pathology. Temporal orienting has been linked to activity in the left inferior parietal cortex and, in contrast to duration estimation tasks, reflects the ability to pinpoint when an event happens rather than evaluating how long it lasts.

12h – 12h30. Short talk. Motor contribution to auditory temporal predictions. *Benjamin Morillon.*

Temporal predictions are fundamental instruments for facilitating sensory selection, allowing humans to exploit regularities in the world. Recent evidence indicates that the motor system instantiates predictive timing mechanisms, helping to synchronize temporal fluctuations of attention with the timing of events in a task-relevant stream, thus facilitating sensory selection. Accordingly, in the auditory domain auditory-motor interactions are observed during perception of speech and music, two temporally structured sensory streams. I will present a behavioral and neurophysiological account for this theory and will detail the parameters governing the emergence of this auditory-motor coupling, through a set of behavioral and magnetoencephalography (MEG) experiments. I will first review the prominence of delta (~2 Hz) oscillatory rhythms in the motor cortex and show that they constraint the interaction between motor and auditory systems. At this rate –and this rate only– overt rhythmic movements sharpen the temporal selection of auditory stimuli, thereby improving performance. I will next show that the implication of the motor system during auditory perception depends also on the temporal predictability of the sensory stream. Behaviorally, the feeling of groove induced by a melody –i.e. the wanting to move during passive listening– strongly depends on its temporal predictability. MEG results reveal that auditory and motor regions have a distinctive sensitivity to auditory temporal dynamics, with motor areas being more flexible in their ability to track temporal information. Together, these findings are compatible with active sensing theories, emphasizing the prominent role of motor areas in sensory processing, which are notably implicated in the analysis of contextual temporal information.

14h – 15h. Keynote. The topographic representation of time in human brain. *Domenica Bueti.*

How is millisecond unit of time represented in the brain? In my talk I will focus on a possible mechanism of duration representation in the human brain: via duration tuning and topography. Specifically, I will present a series of high-spatial resolution functional magnetic resonance imaging (fMRI at 7 Tesla) studies in which I show the existence of a wide network of brain areas displaying selective responses to stimulus duration and topographically organized on the cortical surface as to form “chronomaps”. Through distinct experiments in which we change the sensory modality (visual and auditory), the task at hand and the temporal context of the stimuli, we try to define the functional properties of chronomaps (e.g., modality and task specificity, perceived versus physical time representation, interactions with numerosity maps). These findings although intriguing since they show that a very abstract and intangible feature of our experience can be represented in the brain in a seemingly categorical fashion, leave a number of questions open and present some limitations that I will also discuss in the talk.

16h30 – 17h30. Keynote. How movements shape the perception of time. *Martin Wiener.*

Movement and time are naturally intertwined. However, while it has long been known that our sense of time can affect our movements, relatively recent research has begun to also show the converse – that our movements can affect the sense of time. Here, I will present recent work that displays this relationship, in which movements, either performed, imagined, or observed, can influence the perception of time. Through this work, which relies on measuring precise kinematics of the observer, two phenomena are found: movements can both enhance our sense of time and bias it. To explain these effects, I will present a model of Bayesian cue combination, in which movements afford the most precise representation of temporal intervals. Further, two modes of neural instantiation will be presented, in which movements can influence time either through "active sensing", in which they shape responses directly in sensory cortices, or "feedforward enhancement", in which downstream activity in motor regions alters the memory for timed events. Evidence for both modes will additionally be presented. Further, cue combination provides several predictions of how movements should affect time estimates; a final series of experiments will be presented that address these predictions. Altogether, these results suggest that humans engage the motor system while measuring intervals of time, even when overt movements are not required for the task.

POSTER PRESENTATIONS ABSTRACTS

15h30 – 16h30. Poster. Does rhythmic motor behavior help listeners parse speech presented in noise? *Noémie te Rietmolen.*

The current project concentrates on the role of motor activity in temporal predictions during speech processing. Previous research has shown that temporal predictions allow for the brain to maximize sensitivity at those moments in time expected to be most critical for optimal perception. The motor cortex is suggested to facilitate the implementation of such temporal predictions, and may, as such, directly impact the perception of temporally structured sensory signals such as speech. Indeed, direct motor cortex activation through overt finger-tapping has been shown to encode temporal information and improve participants' ability to segment auditory information. However, whether such direct motor activation similarly enhances the perception of speech remains an open question. Here we set out to answer this question and investigated whether activating the motor cortex through an overt tapping task helps listeners perceive speech presented in noise. Preliminary results indicate that tapping along a rhythmic prime facilitates subsequent speech processing, but only when listeners tapped at rates around 2 Hz. In a follow-up control experiment, we show these behavioral benefits to be independent of the rhythmic prime itself, but instead depend on the overt motor activity. These results indicate that engaging the motor system through overt rhythmic movement helps listeners perceive speech presented in noise, likely by enhancing temporal predictions and allowing the listeners to allocate their attention to the more crucial time points in the speech signal. Because we additionally observed the tapping benefits to be rate-specific to the ~2 Hz rate, i.e. the rate is close to the lexical rate, the results may furthermore reveal a preference for parsing utterances at the word level.

15h30 – 16h30. Poster. Motor contributions to predictive timing during music listening. *Arnaud Zalta.*

When do motor dynamics contribute to auditory perception and what computations underlie this phenomenon? To test the hypothesis that motor engagement depends on the predictive timing of auditory streams, we built melodies of varying degrees of syncope. We observed a quadratic relationship between syncope and motor involvement, characterized by the urge to move during passive listening (groove). Magnetoencephalography data show that auditory regions track the rhythm of the melodies. Intrinsic neural dynamics instead encode the groove in motor beta dynamics and at 1.4 Hz -the perceptual rhythm of auditory temporal attention- in the left auditory dorsal pathway. Critically, the left parietal cortex subtends the coupling between these 1.4 Hz and beta dynamics, the latter being then relayed via the SMA up to the motor cortex. These results are captured by a computational model of coupled oscillators, suggesting that auditory temporal attention involves motor processes when auditory streams are temporally complex but predictable.

15h30 – 16h30. Poster. A new protocol to assess the influence of gravity in temporal cognition in rats. *Emna Marouane.*

To navigate efficiently, movements duration needs to be assessed. Interestingly, astronauts display alterations in spatial navigation abilities and a change in the subjective perception of time during their stay in the International Space Station (ISS). The vestibular system detects vertical linear acceleration; it is therefore particularly affected by changes in gravity. The vestibular nuclei located in the brainstem are the first relay of integration of vestibular receptors located in the inner ear. They send indirect projections to the hippocampus and the striatum, and that could be one of the key mechanisms of these modifications of perceptions. Different techniques exist to explore the role of the vestibular system, but, strikingly, there is a lack of behavioral tests to evaluate time perception adapted to vestibular rodent models. We propose here a new behavioral test to assess the influence of the vestibular system on temporal cognition in rats. After learning the task, the animal will be submitted to modification of vestibular inputs. This protocol will give new insights on the role of the vestibular system in time perception.