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Time Order is a Psychological Bias

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Inter-individual variability in temporal order perception has rarely been tackled empirically although readily observed in the literature. Classically, temporal order perception has been studied using temporal order judgements (TOJ) in which participants report the order of two stimuli presented few milliseconds apart. The temporal delay, at which participants consider the order of stimuli to be at chance is called Point of Subjective Simultaneity (PSS) and is typically averaged across participants canceling out potential individual effects. Here, we asked whether an individual's PSS was stable over weeks, which would indicate an intrinsic or hardwire constant delay in perceptual systems. The present work aimed to test this stability and to distinguish this hypothesized intrinsic constant from an attentional effect, considering that temporal order perception is known to be modulated by attentional fluctuations. We designed a longitudinal psychophysics study using auditory, visual, and audiovisual TOJs. The experimental design also comprised unisensory (vision or audition attended) and divided (audition and vision attended) attentional conditions. A standard measure of PSS was extracted from the divided attentional condition, and a measure of PSS free of any attentional biases was computed from the unisensory attentional conditions. Our results show that individual standard PSS are stable over months, strengthening the hypothesis that the PSS is an individual marker of temporal perception and thus a defining feature of an individual's core biases. Attention could partially, but not fully, compensate for this bias. We measured the neural oscillatory activity with magnetoencephalography during a TOJ task and this study revealed that perception of temporal order cannot be predicted if the individual biases are not taken into account. These results shed a new light in the debated issue of what is actually measured in a TOJ and stressed the importance to tackle individual differences.

Keywords: temporal order, interindividual variability, multisensory, attention, time consciousness

*Speaker

Adult-born neurons boost odor-reward association

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Olfaction is an important sensory modality in rodents, driving fundamental behaviors. Most odors elicit responses acquired following learning, as the assignment of a positive value to a given odorant. These odor-reward associations require multiple forms of plasticity. In the olfactory bulb, one of the main mechanism of plasticity is the arrival of thousands of new neurons every day through adulthood. However, if adaptative odor value encoding has been described in different regions of the olfactory system, its relevance at early sensory stages, as well as the involvement of adult-born neurons, remain still unknown. Here, we demonstrate that exposure to reward-associated odors increases activity in adult-born neurons, but not in neonatal-born neurons. Moreover, activating these adult-born neurons by optogenetics specifically during rewarded odor presentation improves discrimination learning, and odor value update during reversal association. Taken together, our results show a specific involvement of adult-born neurons in odor-reward association during adaptative learning.

Keywords: olfactory bulb, adult neurogenesis, associative learning, reward

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Bilateral discrimination of tactile patterns without whisking in freely-running rats

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A majority of the current tactile discrimination tasks in rodents are carried out on head-fixed animals, to facilitate tracking or control of the sensory inputs. However, the fixation of the head critically restrains the possibilities of applying stimuli that mimic those occurring in natural conditions. Notably, the simultaneous discrimination of tactile patterns on both sides of the snout in freely-behaving rats has not yet been explored. We developed a two-alternative forced-choice task in an automated modified T-maze. Stimuli were either a surface with no bars (smooth), or with vertical bars spaced irregularly or regularly. While running at full speed in a corridor, rats encountered the two discriminanda simultaneously on the right and left side of the whisker pad. They had to turn to the side of the regular grating (rewarded stimulus) at the end of the corridor. Rats (n=6 rats) learnt to recognize tactile regular bars against smooth surfaces in eight weeks. Both clipping of the whiskers (n=7 rats) and S1 cortical inactivation with muscimol (n=3 rats) significantly decreased performance. Whisker tracking analysis (n=3 rats) revealed that rats do not whisk while solving the task, but rather actively positionned their whiskers when they encounter the stimuli. To conclude, rats were able to discriminate sequences of bars on a surface by scanning the stimuli just once. We showed that the whisker system and S1 activity are involved during the discrimination process. We hypothesize that in S1 a precise spike timing coding for stick/slip events could underlie this tactile ability. We are currently recording neuronal activity from the thalamo-cortical loop to investigate the responses evoked by the movements of the whiskers in contact with the regular, irregular and smooth stimuli.

Keywords: tactile, whiskers, discrimination

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Brain mechanisms of the arithmetic problem-size effect: a crucial role for ventral temporal cortex

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When we compute an addition, calculation time increases with the size of the numbers involved. This problem-size effect is a fundamental property of mental arithmetic, yet its neural basis remain poorly understood. The classical view, arising from functional magnetic resonance imaging (fMRI), is that the intraparietal sulcus (IPS) is the main hub for arithmetic, where fMRI activity increases with problem size. However, recent studies using electrocorticography (ECoG) have discovered a specific site, within the posterior inferior temporal cortex (pITG), that activates during visual perception of numerals with widespread adjacent responses when numerals are used in calculation. Here, we re-examined the contribution of the IPS and pITG regions to arithmetic by recording ECoG signals from 10 subjects solving addition problems. At parietal sites around the IPS, total high-frequency broadband (HFB) activity increased with problem size, corroborating previous fMRI findings. More surprisingly, pITG sites showed an initial burst of HFB activity that decreased as the operands got larger, yet with a constant integral over the whole trial, thus making these signals invisible to slow fMRI. While parietal sites appear to have a more sustained role in arithmetic decision making, the pITG may index the semantic evidence available for a calculation, independently of the visual properties of the stimuli. Our results challenge the traditional view of the ventral temporal cortex and reveal its involvement in symbolic forms of reasoning, such as mental calculation.

Keywords: electrocorticography, mental arithmetic, problem, size effect, ventral temporal cortex, intraparietal sulcus

*Speaker

Seeing colour where there is none: Decoding the implied colour of grey-scale objects using MEG

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Natural objects in our environment often have canonical colours that influence our recognition and decision-making. For example, the colour of a strawberry is useful when deciding whether it is ripe and edible. In the current study, we asked participants to do a simple target-detection task when looking at either isoluminant red and green shapes or grey-scale luminance-matched pictures of fruits and vegetables that in 'real life' would be red (e.g., strawberry) or green (e.g., cucumber). We recorded brain activity using Magnetoencephalography (MEG) to investigate (1) the temporal dynamics of real colour processing, (2) whether grey-scale pictures of red and green fruits and vegetables can be classified into their colour category, and (3) whether there are commonalities in the processing of real colour and implied object-colour. Applying Multi Voxel Pattern Analysis (MVPA) to our time-series neuroimaging data, we were able to successfully classify the real colour objects into red and green categories early in the signal. Similarly, we could classify trials showing grey-scale pictures of fruits and vegetables into their natural colour categories. Finally, we were able to decode implied object-colour when the classifier is trained on distinguishing real colour, but this cross-classification was only possible using time-generalisation methods showing that there are temporal asynchronies in processing real colour and implied colour. Together, these results demonstrate that there are similarities in brain representation of real and implied colour but that object colour knowledge is accessed later than real colour.

Keywords: colour vision, perceptual knowledge, decoding, MVPA, MEG

*Speaker

Mesencephalic origin of the preglomerular nucleus and the inferior lobe of the "hypothalamus" in zebrafish

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Although the overall plan of construction of the brain is conserved throughout vertebrates, significant differences exist within each brain region. Current models of the brain organization are largely based on a mammalian-centric point of view, but comparative analyses including teleost brains provide new perspectives on the general organization of the vertebrate brains.
We here demonstrate that some teleost structures that have been considered to be prosencephalic (forebrain) are actually mesencephalic. At 24 hours post-fertilisation (hpf), the transcription factor *her5* is specifically expressed in progenitors of the midbrain hindbrain boundary (MHB). By taking advantage of existing transgenic lines, we could trace progenies of these cells.

We have found that a fraction of the MHB originating cells participates in the formation of the preglomerular nucleus (PG) and the inferior lobe (IL). PG is a major sensory relay nucleus in teleosts, similarly to the thalamus in amniotes. The PG has been thought to be located in the ventral diencephalon called the posterior tuberculum. Our data show that an important ventral portion of the PG originates from the MHB, suggesting that the similar functional properties found in the amniote thalamus and the teleost PG are convergent evolution. The inferior lobe (IL) is a structure that is not found in tetrapods. It develops around the caudolateral elongation of the lateral recess (LR) and was assumed to be the posterior part of the hypothalamus. Our data show that the cells around the ventricular zones of LR are hypothalamic, but outer cells forming the majority of the IL are actually mesencephalic.
These results support that in spite of the functional and behavioral similarities observed, there are important variations in brain structures when comparing different vertebrate groups.

Keywords: evolution, neuroanatomy, brain development, teleosts

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Maximal entropy models of human cortical activity during wakefulness and sleep

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Underlying the brain states of wakefulness and sleep, cortical neural network dynamics display great complexity. Using models from statistical physics, we uncover the characteristics of such activity in a hundred neurons recorded by multielectrode array in a human subject's temporal cortex (Peyrache et al, PNAS, 2012).

To evaluate the role of pairwise interactions in the dynamics, we applied an Ising model, the most generic (maximum entropy) model to reproduce the neuron's pairwise covariances to our data. We successfully inferred the model parameters from the data thanks to the inference algorithm introduced by (Ferrari, Phys. Rev. E, 2016). The statistical properties of neural dynamics during wakefulness are successfully reproduced, while during Slow-Wave Sleep (SWS) the model notably fails to reproduce transients of high network activity. From a first insight, this may be caused by the synchronous population-wide inhibitory cell dynamics, extending beyond pairwise interactions.

This is consistent with recent findings (Okun et al, Nature, 2015), emphasising that single cell activity can be governed by population dynamics. To investigate the relevance of this approach to our data, we utilise another maximum entropy model with the couplings of each neuron to the population as parameters, based on the model from (Gardella et al, eneuro, 2016). We are currently refining the model to take into account each neuron's interactions with the excitatory and the inhibitory populations separately. From preliminary results, this model accurately accounts for the observed excitatory/inhibitory difference in dynamics, and allows for the investigation of neurons' synchronous dynamics during SWS.

Our first results tend to suggest that neurons' dynamics during wakefulness is dominated by pairwise interactions, while neural activity during sleep may be governed by longer-range population-wide interactions.

Keywords: human temporal cortex, brain states, Slow, Wave Sleep, maximal entropy models, pairwise Ising model

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Electrophysiological evidence for Cerebello-Hippocampal interactions

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The latest findings from Rondi-Reig (CEZAME) team have pointed towards a bidirectional cerebello-hippocampal interaction that is important for the correct establishment and use of the hippocampal spatial code. By injecting retrograde transneuronal tracers into the hippocampus the group has identified discrete anatomically connected regions in the cerebellar cortex that could be part of the underlying pathways supporting these interactions: lobule VI and the crus I of the posterior cerebellum and in the paraflocculus, part of the vestibulocerebellum.
In order to study the levels of functional interaction between these regions from an electrophysiological perspective, we calculated coherence (previously described as a useful proxy to this end) between simultaneously recorded local field potentials from the hippocampus and different lobules of the cerebellar cortex in behaving mice.

Recorded cerebellar regions included either those anatomically connected with the hippocampus (lobule VI and Crus I) or non-connected control regions (lobule II/III). We measured coherence during different behavioural states: active movement in a familiar environment (home-cage) and active movement in both a real world and virtual reality (head-fixed condition) linear track task. The electrophysiological results are in agreement with the anatomy: the coherence between the recorded LFPs from the hippocampus and the different cerebellar cortical regions was significantly higher in anatomically connected combinations compared with the non-connected controls. We also found that the coherence levels were dynamic and depend upon the particular behavioural state.

Keywords: Cerebellum, hippocampus, electrophysiology

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