Sat. Oct 18, 2025

Oral | Memory, Emotion, Decision

Sat. Oct 18, 2025 9:00 AM - 10:30 AM JST | Sat. Oct 18, 2025 12:00 AM - 1:30 AM UTC Room 3(East B1)

[20301-06] Oral 4: Memory, Emotion, Decision

Chair:Müge Cavdan(Justus Liebig University Giessen)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[20301-06-01]

Investigating the effect of emotion on the temporal resolution of visual processing in viewing flickering LED.

*Makoto Ichikawa[1], Misa Kobayashi[2] (1. Graduate School of Humanities, Chiba University (Japan), 2. Graduate School of Science and Engineering, Chiba University (Japan))

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[20301-06-02]

Alpha power indexes working memory load for durations

*Sophie Herbst[1], Izem Mangione[1], Charbel-Raphael Segerie[2], Richard Höchenberger[2], Tadeusz Kononowicz[4,1,3], Alexandre Gramfort[2], Virginie van Wassenhove[1] (1. Cognitive Neuroimaging Unit, INSERM, CEA, Université Paris-Saclay, NeuroSpin, 91191 Gif/Yvette, France (France), 2. Inria, CEA, Université Paris-Saclay, Palaiseau, France (France), 3. Institute of Psychology, The Polish Academy of Sciences, ul. Jaracza 1, 00-378 Warsaw, Poland (Poland), 4. Institut NeuroPSI - UMR9197 CNRS Université Paris-Saclay (France))

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[20301-06-03]

Mentally shifting in time induces a shift in the amplitude of evoked responses

*Anna Maria Augustine Wagelmans[1], Virginie van Wassenhove[1] (1. Cognitive Neuroimaging Unit, INSERM, CEA, Université Paris-Saclay, NeuroSpin (France))

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[20301-06-04]

Mental Time Travel Impairments in Neurodegenerative Diseases

*Valentina La Corte[1,2], Pascale Piolino[1,2] (1. Memory, Brain and Cognition lab,UR 7536, University Paris Cité (France), 2. Institut Universitaire de France (France))

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[20301-06-05]

Level of Detail in Near and Far Future Imagined Events

*Ori Levit[1], Guy Grinfeld[1], Cheryl Wakslak[2], Yaacov Trope[3], Nira Liberman[1] (1. School of Psychological Science, Tel Aviv University (Israel), 2. Department of Management and Organization, University of Southern California, Los Angeles, California (United States of America), 3. Department of Psychology, New York University, New York (United States of America))

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[20301-06-06]

Perceptual decision making of nonequilibrium fluctuations

*Aybüke Durmaz[1], Yonathan Sarmiento[1,2], Gianfranco Fortunato[1], Debraj Das[2], Mathew Ernst Diamond[1], Domenica Bueti[1], Édgar Roldán[2] (1. Sissa (International School for Advanced Studies) (Italy), 2. ICTP (The Abdus Salam International Centre for Theoretical Physics) (Italy))

Oral | Prediction, Temporal perception, Computational Modeling

Sat. Oct 18, 2025 1:00 PM - 2:30 PM JST | Sat. Oct 18, 2025 4:00 AM - 5:30 AM UTC Room 3(East B1)

[O6] Oral 6: Prediction, Temporal perception, Computational Modeling

Chair:Pascal Mamassian(CNRS & Ecole Normale Supérieure Paris)

1:00 PM - 1:15 PM JST | 4:00 AM - 4:15 AM UTC

[O6-01]

Temporal Prediction through Integration of Multiple Probability Distributions of Event Timings

*Yiyuan Teresa Huang[1], Zenas C Chao[1] (1. International Research Center for Neurointelligence, The University of Tokyo (Japan))

1:15 PM - 1:30 PM JST | 4:15 AM - 4:30 AM UTC

[O6-02]

The anticipation of imminent events is time-scale invariant

*Matthias Grabenhorst[1,2], David Poeppel[3], Georgios Michalareas[4,1,2] (1. Ernst Struengmann Institute for Neuroscience (Germany), 2. Max Planck Institute for Empirical Aesthetics (Germany), 3. New York University (United States of America), 4. Goethe University (Germany))

1:30 PM - 1:45 PM JST | 4:30 AM - 4:45 AM UTC

[O6-03]

The timing of neural-cardio-respiratory network states predicts perception across the senses

*Andreas Wutz[1] (1. University of Salzburg (Austria))

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[O6-04]

What does the Fröhlich effect tell us about sensation time?

*Pascal Mamassian[1] (1. CNRS & Ecole Normale Supérieure Paris (France))

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[O6-05]

Oscillatory Entrainment in Non-Deterministic Continuous Environments, Independent of Bayesian Interval Learning: Computational and Behavioral Evidence

*Elmira Hosseini[1,2], Assaf Breska[1] (1. Max-Planck Institute for Biological Cybernetics (Germany), 2. Tübingen University (Germany))

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[O6-06]

An investigation of auditory rhythms with a spiking neural network autoencoder

*Rodrigo Manríquez[1,2], Sonja A. Kotz[2,3], Andrea Ravignani[4,5], Bart de Boer[1] (1. Vrije Universiteit Brussel (Belgium), 2. Maastricht University (Netherlands), 3. Max Planck Institute for Human Cognitive and Brain Sciences (Germany), 4. Sapienza University of Rome (Italy), 5. Aarhus University & The Royal Academy of Music (Denmark))

Oral | Computational Modeling, Neural Mechanisms

Sat. Oct 18, 2025 9:00 AM - 10:30 AM JST | Sat. Oct 18, 2025 12:00 AM - 1:30 AM UTC Room 2(West B1)

[O5] Oral 5: Computational Modeling, Neural Mechanisms

Chair:Assaf Breska(Max-Planck Institute for Biological Cybernetics)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[O5-01]

Centralized mechanisms of explicit and implicit timing in the human cerebellum: a neuropsychological approach

*Chiara Zanonato[1,2], Richard Ivry[3,4], Assaf Breska[1,3] (1. Max-Planck-Institute for Biological Cybernetics, Tübingen (Germany), 2. University of Tübingen (Germany), 3. Department of Psychology, University of California, Berkeley, CA (United States of America), 4. Helen Willis Neuroscience Institute, University of California, Berkeley, CA (United States of America))

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[O5-02]

Unique Effect of Entrainment on Perception? Context-Specific Temporal Prediction Mechanisms in Multiple Aspects of Perception

*Christina Bruckmann[1,2], Assaf Breska[1] (1. Max Planck Institute for Biological Cybernetics (Germany), 2. University of Tübingen (Germany))

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[O5-03]

Rationalizing temporal decision making and the neural representation of time

*Marshall G Hussain Shuler[1,2] (1. Johns Hopkins (United States of America), 2. Kavli Neuroscience Discovery Institute (United States of America))

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[O5-04]

A Methodology to Accelerate Our Information Processing Toward Revealing the Relation between Process Speed and Time Perception

*Oki Hasegawa[1], Shohei Hidaka[1] (1. Japan Advanced Institute of Science and Technology (Japan))

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[O5-05]

Sensory Reliability Shapes Sequential Effects in Human Duration Perception

*Taku Otsuka[1,2], Joost de Jong[1,3], Wouter Kruijne[1], Hedderik van Rijn[1] (1. University of Groningen (Netherlands), 2. The University of Tokyo (Japan), 3. Université de Paris (France))

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[O5-06]

Bach and Bayes: Prediction in Noisy Musical Sequences

*Akanksha Gupta[1], Alejandro Tabas[2,3] (1. INS, INSERM, Aix-Marseille University, Marseille (France), 2. Perceptual Inference Group, Basque Center on Cognition, Brain and Language, San Sebastian (Spain), 3. Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig (Germany))

Oral | Memory, Emotion, Decision

Sat. Oct 18, 2025 9:00 AM - 10:30 AM JST | Sat. Oct 18, 2025 12:00 AM - 1:30 AM UTC Room 3(East B1)

[20301-06] Oral 4: Memory, Emotion, Decision

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Investigating the effect of emotion on the temporal resolution of visual processing in viewing flickering LED.

*Makoto Ichikawa[1], Misa Kobayashi[2] (1. Graduate School of Humanities, Chiba University (Japan), 2. Graduate School of Science and Engineering, Chiba University (Japan))

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[20301-06-02]

Alpha power indexes working memory load for durations

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9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[20301-06-03]

Mentally shifting in time induces a shift in the amplitude of evoked responses

*Anna Maria Augustine Wagelmans[1], Virginie van Wassenhove[1] (1. Cognitive Neuroimaging Unit, INSERM, CEA, Université Paris-Saclay, NeuroSpin (France))

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[20301-06-04]

Mental Time Travel Impairments in Neurodegenerative Diseases

*Valentina La Corte[1,2], Pascale Piolino[1,2] (1. Memory, Brain and Cognition lab,UR 7536, University Paris Cité (France), 2. Institut Universitaire de France (France))

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[20301-06-05]

Level of Detail in Near and Far Future Imagined Events

*Ori Levit[1], Guy Grinfeld[1], Cheryl Wakslak[2], Yaacov Trope[3], Nira Liberman[1] (1. School of Psychological Science, Tel Aviv University (Israel), 2. Department of Management and Organization, University of Southern California, Los Angeles, California (United States of America), 3. Department of Psychology, New York University, New York (United States of America))

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[20301-06-06]

Perceptual decision making of nonequilibrium fluctuations

*Aybüke Durmaz[1], Yonathan Sarmiento[1,2], Gianfranco Fortunato[1], Debraj Das[2], Mathew Ernst Diamond[1], Domenica Bueti[1], Édgar Roldán[2] (1. Sissa (International School for Advanced Studies) (Italy), 2. ICTP (The Abdus Salam International Centre for Theoretical Physics) (Italy))

Investigating the effect of emotion on the temporal resolution of visual processing in viewing flickering LED.

*Makoto Ichikawa[1], Misa Kobayashi[2]

1. Graduate School of Humanities, Chiba University, 2. Graduate School of Science and Engineering, Chiba University

We investigated how emotional responses with different degrees of valence and arousal evoked by viewing a photograph of various facial expressions affects temporal resolution of the visual processing. In Experiment 1, we measured the critical flicker-fusion frequency (CFF) as an index of temporal resolution of visual processing. We used the method of constant stimuli to measure CFF. We presented facial photographs with different expressions (anger, sad, or neutral) in an upright or an inverted orientation. Then, we presented flickering LED with seven different temporal frequencies of LED flicker, and the stimuli in which the duration of on and off of LED was 5ms (100 Hz) as catch stimuli. In each trial, participants reported whether they found the LED flickered or consistent by pressing keys. We found that CFF was smaller for the angry face than for the neutral face only with the upright presentation. In Experiment 2, we measured the detection rate of LED flicker with different ISI (20 or 100ms) between the facial photographs with different expressions (fear, sad, or neutral) and flicker of LED. We prepared four temporal frequency conditions for the LED flashing (15, 17, 19 ms conditions of the on-off of the flashing, and no flickered-consistent condition). Participants reported whether they found the LED flickered or consistent by pressing keys. Results showed that the detection rate for fearful face was significantly higher than the detection rate of the neutral face, and that the detection rate correlated with rating for arousal positively, and with rating for valence negatively only at short ISI. These results suggest that emotion evoked by viewing pictures may elevate the temporal resolution of the visual processing which was measure as CFF only with the upright presentation, and that this effect would decay within short period.

Keywords: critical flicker-fusion frequency, arousal, valence, facial expression, method of constant stimuli

Alpha power indexes working memory load for durations

*Sophie Herbst[1], Izem Mangione[1], Charbel-Raphael Segerie[2], Richard Höchenberger[2], Tadeusz Kononowicz[4,1,3], Alexandre Gramfort[2], Virginie van Wassenhove[1]

1. Cognitive Neuroimaging Unit, INSERM, CEA, Université Paris-Saclay, NeuroSpin, 91191 Gif/Yvette, France, 2. Inria, CEA, Université Paris-Saclay, Palaiseau, France, 3. Institute of Psychology, The Polish Academy of Sciences, ul. Jaracza 1, 00-378 Warsaw, Poland, 4. Institut NeuroPSI - UMR9197 CNRS Université Paris-Saclay

Seminal models of explicit duration perception include a working memory component, serving the comparison between just encoded durations and durations stored in long-term memory. Yet, neither time perception models, nor time memory models provide clear predictions as to the representation of duration in memory. Previously, we have been able to show based on a novel n-item delayed reproduction task, that the precision of duration recall decreases with the number of items to be remembered in sequence, but not with the duration of the sequence (Herbst et al., 2025). This suggests that durations are maintained as discrete items, rather than a continuous temporal code. Here, we investigated the neural signatures of a sequence of durations (n-item sequence) held in working memory. We recorded human participants using magnetoencephalography (MEG) while they performed the n-item delayed reproduction task, which required to encode a sequence of durations, maintain it, and then reproduce it. The number of items in a sequence (one or three) and the duration of the sequence were varied orthogonally. Our results show that during working memory maintenance, the number of durations, but not the duration of the sequence, affected recall precision and could be decoded from alpha and beta oscillatory activity. Parieto-occipital alpha power showed a direct link with the precision of temporal reproduction. Our results extend the earlier behavioral findings suggesting that durations are itemized in working memory and that their number, not their duration, modulates recall precision. Crucially, we establish that alpha power reflects a universal signature of working memory load and mediates recall precision, even for abstract information such as duration.

Keywords: duration perception, working memory, alpha oscillations, beta oscillations, duration reproduction

Mentally shifting in time induces a shift in the amplitude of evoked responses

*Anna Maria Augustine Wagelmans[1], Virginie van Wassenhove[1]

1. Cognitive Neuroimaging Unit, INSERM, CEA, Université Paris-Saclay, NeuroSpin

Through mental time travel (MTT), humans can explore past events or possible futures. One hypothesis is that MTT builds on flexible temporal cognitive maps of events' position in time (Gauthier & van Wassenhove, 2016). Previous studies have shown the implication of the hippocampal-entorhinal system for MTT (Gauthier et al., 2019; 2020), where the sequential firing of neuronal assemblies on shifting phases of theta oscillations codes for spatial position and distance (Dragoi & Buzsáki, 2006). Yet, the computation of temporal distances remains to be characterized. In a novel paradigm (N = 63), participants mentally projected themselves to different dates in the past or future. They were shown historical events, and had to report whether the event would happen before or after, with respect to their temporal position. We found that the further away in time participants imagined themselves to be, the slower their reaction times. This parametric shift shows that distance computations can be captured during MTT at a behavioural level, and grounds the hypothesis of a similar shift in neural responses. Herein, we adapted this task to magnetoencephalography (N = 31). We show that the amplitude of neural responses evoked by mentally projecting in time increased compared to being in the present, but did not shift along temporal distance. This suggests that the evoked response captures the operation of mentally projecting oneself in time, but not the underlying distance computations. Source reconstruction based on anatomical scans is ongoing to identify the regions contributing to this increase in evoked activity, with a primary focus on the hippocampus.

Keywords: mental time travel, cognitive map, MEG, hippocampus

Mental Time Travel Impairments in Neurodegenerative Diseases

*Valentina La Corte[1,2], Pascale Piolino[1,2]

1. Memory, Brain and Cognition lab,UR 7536, University Paris Cité , 2. Institut Universitaire de France

In recent decades, research on memory processes has expanded to include the mechanisms involved in envisioning future events, within the broader framework of mental time travel (MTT). *Prospection* refers to a broad and complex set of cognitive processes that enable individuals to anticipate, plan for, and mentally simulate future experiences.This study focuses on a specific form of episodic prospection known as episodic future thinking (EFT)—the capacity to project oneself forward in time to pre-experience personal future events.Previous studies have documented impairments in EFT among individuals with neurodegenerative diseases such as Alzheimer’ s disease (AD) and semantic dementia (SD), often related to long-term memory deficits. However, the neurocognitive mechanisms underlying these deficits remain poorly understood—particularly regarding the role of temporal distance.The aims of the present study were:
(i) to investigate MTT capacities across different temporal distances in AD and SD patients;
(ii) to disentangle the relationship between EFT and long-term memory deficits in these neurodegenerative profiles.Our results show that AD patients exhibited significant impairments in EFT for near-future events, while their performance for distant-future scenarios was relatively preserved. Additionally, they demonstrated deficits in past event recollection regardless of temporal distance. In contrast, SD patients showed an opposite pattern: preserved EFT for near and intermediate future events, but impaired performance for distant ones. Regarding the past dimension, SD patients showed deficits specifically for remote events.These findings contribute to a more nuanced understanding of how episodic and semantic memory impairments differentially affect past and future-oriented cognition in neurodegenerative conditions. The results carry both theoretical significance and potential clinical applications.

Keywords: mental time travel, memory, neurodegenrative diseases, personal temporality, episodic future thinking

Level of Detail in Near and Far Future Imagined Events

*Ori Levit[1], Guy Grinfeld[1], Cheryl Wakslak[2], Yaacov Trope[3], Nira Liberman[1]

1. School of Psychological Science, Tel Aviv University, 2. Department of Management and Organization, University of Southern California, Los Angeles, California, 3. Department of Psychology, New York University, New York

How does psychological distance influence the level of detail in our mental representations of future imagined events? According to Construal Level Theory (CLT), there are four psychological distance dimensions: events can feel distant in time (temporal), space (spatial), social relationship (social), or probability (hypothetical). Yet we lack direct measures of how these distances affect the level of detail in mental representations. We bridged this gap by adapting Reality Monitoring Theory's Memory Characteristics Questionnaire to measure the level of detail in future imagined scenarios. Across six studies (N=1,749), we demonstrated that psychological distance, including the temporal dimension, systematically reduces the level of detail in mental imagery. Study 1 found that more psychologically distant imagined scenarios were rated as significantly less detailed ($r = -.16$, $p = .005$). Studies 2-3 manipulated hypotheticality, showing that probable future meetings were imagined with greater detail than improbable future meetings ($d = 0.47$, $p < .001$). Study 4 examined the same idea in spatial distance ($d = 0.20$, $p = .007$), and Study 5 examined social distance ($d = 0.31$, $p = .01$). Study 6 specifically examined temporal distance: older adults closer to retirement age imagined their future retirement with greater detail than younger adults ($r = .23$, $p < .001$), and this increased temporal detail mediated the relationship between temporal closeness and actual retirement savings behavior (indirect effect: $b = 0.06$, 95% CI [0.01, 0.03]). These findings demonstrate that psychological distance systematically affects the level of detail in future mental representations. For timing research, this reveals how temporal distance affects mental representation: feeling temporally closer to events increases mental detail, which influences real-world planning behavior

Keywords: Psychological Distance, Temporal Distance, Mental Imagery, Future thinking, Construal level

Perceptual decision making of nonequilibrium fluctuations

*Aybüke Durmaz[1], Yonathan Sarmiento[1,2], Gianfranco Fortunato[1], Debraj Das[2], Mathew Ernst Diamond[1], Domenica Bueti[1], Édgar Roldán[2]

1. Sissa (International School for Advanced Studies), 2. ICTP (The Abdus Salam International Centre for Theoretical Physics)

A pedestrian deciding when to cross a busy street must consider not only the average traffic flow but also the fluctuations in the movement of individual cars. Similarly, the perceptual system must handle both local fluctuations in individual elements and the global patterns that emerge from their interactions. To investigate how the brain makes efficient decisions in such nonequilibrium systems—where evidence changes over time—we conducted three experiments with sixty-seven human participants who judged the direction of a particle exhibiting drifted Brownian motion. The entropy production rate extracted from the particle's trajectory served as a measure of noise dynamics.

We found that mean decision time was inversely proportional to the entropy production rate, establishing an analytical approach to predict the amount of time required to extract the signal given stimulus parameters. Moreover, participants required more time than predicted, indicating suboptimal decision times. An evidence integration approach, equipped with a memory time constant, resulted in tighter fits, indicating that participants adjusted their integration time window to stimulus dissipation, favoring the global trajectory of the stimulus over local fluctuations when the stimuli exhibited higher entropy production.

Furthermore, comparisons between blocked and intermixed conditions revealed that environmental stability was directly linked with decision optimality as well as the flexibility in adjusting integration time window. Complementary approaches indicated that decision optimality was linked to (I) memory load, (II) the recency effect, and (III) the ability to detect meaningful statistical cues in the evidence.

Overall, our work shows that providing a detailed model of the physical properties of the stimuli allows for a better characterization of the variables influencing perceptual decision-making, and refines our understanding of the temporal dynamics of efficient evidence integration.

Keywords: perceptual decision making, nonequilibrium systems, decision optimality, evidence integration, stimulus statistics, integration time window

Oral | Prediction, Temporal perception, Computational Modeling

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[O6] Oral 6: Prediction, Temporal perception, Computational Modeling

Chair:Pascal Mamassian(CNRS & Ecole Normale Supérieure Paris)

1:00 PM - 1:15 PM JST | 4:00 AM - 4:15 AM UTC

[O6-01]

Temporal Prediction through Integration of Multiple Probability Distributions of Event Timings

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1:15 PM - 1:30 PM JST | 4:15 AM - 4:30 AM UTC

[O6-02]

The anticipation of imminent events is time-scale invariant

*Matthias Grabenhorst[1,2], David Poeppel[3], Georgios Michalareas[4,1,2] (1. Ernst Struengmann Institute for Neuroscience (Germany), 2. Max Planck Institute for Empirical Aesthetics (Germany), 3. New York University (United States of America), 4. Goethe University (Germany))

1:30 PM - 1:45 PM JST | 4:30 AM - 4:45 AM UTC

[O6-03]

The timing of neural-cardio-respiratory network states predicts perception across the senses

*Andreas Wutz[1] (1. University of Salzburg (Austria))

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[O6-04]

What does the Fröhlich effect tell us about sensation time?

*Pascal Mamassian[1] (1. CNRS & Ecole Normale Supérieure Paris (France))

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[O6-05]

Oscillatory Entrainment in Non-Deterministic Continuous Environments, Independent of Bayesian Interval Learning: Computational and Behavioral Evidence

*Elmira Hosseini[1,2], Assaf Breska[1] (1. Max-Planck Institute for Biological Cybernetics (Germany), 2. Tübingen University (Germany))

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[O6-06]

An investigation of auditory rhythms with a spiking neural network autoencoder

*Rodrigo Manríquez[1,2], Sonja A. Kotz[2,3], Andrea Ravignani[4,5], Bart de Boer[1] (1. Vrije Universiteit Brussel (Belgium), 2. Maastricht University (Netherlands), 3. Max Planck Institute for Human Cognitive and Brain Sciences (Germany), 4. Sapienza University of Rome (Italy), 5. Aarhus University & The Royal Academy of Music (Denmark))

Temporal Prediction through Integration of Multiple Probability Distributions of Event Timings

*Yiyuan Teresa Huang[1], Zenas C Chao[1]

1. International Research Center for Neurointelligence, The University of Tokyo

Our brain uses prior experience to anticipate the timing of upcoming events. This dynamical process can be modeled using a hazard function derived from the probability distribution of event timings. However, the contexts of an event can lead to various probability distributions for the same event, and it remains unclear how the brain integrates these distributions into a coherent temporal prediction. In this study, we create a foreperiod sequence paradigm consisting of a sequence of paired trials, where in each trial, participants respond to a target signal after a specified time interval (i.e. foreperiod) following a warning cue. The prediction of the target onset in the second trial can be based on the probability distribution of the second foreperiod and its conditional probability given the foreperiod in the first trial in the context of foreperiod sequence. These probability distributions are then transformed into hazard functions to represent the temporal predictions. The behavioral model incorporating both of the prediction and the contextual prediction significantly improves fit of reaction times to the target signal, indicating that both regularities of temporal information contribute to making predictions. We further show that electroencephalographic source signals are best reconstructed when integrating both predictions. Specifically, the prediction and the contextual predictions are separately encoded in the posterior and anterior brain regions, and to achieve synergy between both predictions, a third region—particularly the right posterior cingulate area—is needed. Our study reveals brain networks that integrate multilevel temporal information, providing a comprehensive view of hierarchical predictive coding of time.

Keywords: Temporal prediction, Multiple probability distributions, Hazard functions, Forward encoding analysis, EEG source

The anticipation of imminent events is time-scale invariant

*Matthias Grabenhorst[1,2], David Poeppel[3], Georgios Michalareas[4,1,2]

1. Ernst Struengmann Institute for Neuroscience, 2. Max Planck Institute for Empirical Aesthetics, 3. New York University, 4. Goethe University

Humans predict the timing of imminent events to generate fast and precise actions. Such temporal anticipation is critical over the range of hundreds of milliseconds to a few seconds. However, it was argued that timing mechanisms differ below and above a boundary at around 1–2 seconds in time perception and interval discrimination (Grondin, J Exp Psychol, 2012; Gibbon et al., Curr Opin Neurobiol, 1997) and duration discrimination (Rammsayer & Lima, Percept Psychophys, 1991; Rammsayer et al, Frontiers in Psychology, 2015) which may affect timing behavior in the anticipation of imminent events. Recent work showed that the brain models the probability density function of events across time, suggesting a canonical mechanism for temporal anticipation (Grabenhorst et al., Nat Commun, 2019 & 2025). Here we investigate whether this core computation remains stable across the described temporal boundaries when the distribution of events is stretched across different time spans. In a Set - Go task, the time between the two cues was randomly drawn from probability distributions which, across experimental blocks, were defined over different time spans. Participants were asked to react as fast as possible to the Go cues and generated > 52000 reaction times (RT). We found that, irrespective of the time span, anticipation, measured as RT, scales with the event distribution. This shows that the key computation –the estimation of event probability density –is invariant across temporal scales. We further found that the variance in anticipation is also scale invariant which contradicts Weber's law. The results hold in vision and audition, suggesting that the core computations in anticipation are independent of sensory modality. These findings demonstrate that –independent of temporal scale –perceptual systems estimate probability over time to anticipate the timing of future events. We conclude that temporal anticipation, a basic function in cognition, is time-scale invariant.

Keywords: Temporal prediction, Probability estimation, Time estimation, Temporal cognition, Weber's law

The timing of neural-cardio-respiratory network states predicts perception across the senses

*Andreas Wutz[1]

1. University of Salzburg

For the past decades, neuroscience research has repeatedly highlighted the pivotal role of observer-dependent, internal network states predisposing sensory experiences in the external world. Nevertheless, many open questions remain: How are these internally generated processes implemented in the perceiver? How are they controlled and timed relative to each other and to sensory inputs? And, do they generalize across different sensory systems? In this talk, I present novel magneto-encephalography (MEG), cardiac and respiratory data that conclusively demonstrate top-down brain networks influencing perception across different sensory modalities and their relationships to ongoing dynamics in the body. On each trial, different visual, auditory or tactile stimuli were shown at individual perceptual thresholds, such that about half of the stimuli were consciously detected, while the other half were missed. The main findings show neural activity bursts occurring shortly before stimulus onset across frontal and posterior cortex in the brain’s dominant alpha-frequency band rhythm (8-13 HZ). The precise timing of these neural activity bursts is predictive of subsequent perceptual outcomes generalized across all three senses. Moreover, the neural activity bursts happen at specific phases of the participants’ cardiac cycle, suggesting a crucial role of pre-stimulus neural-cardio network timing for conscious perception. Because cardiac activity is strongly coupled to respiration, neural-cardio network interactions may be top-down controlled and timed by the participants’ breathing behavior. In line with this hypothesis, the participants strategically regulate their respiratory activity during the task both relative to stimulus onset and to neural burst onset. The participants’ breath out earlier for successfully detected vs. missed stimuli with respect to the onset of the activity bursts in the brain. Overall, our results reveal an interactive, multi-stage temporal processing cascade bridging both neural and bodily systems and preparing the perceiving organism for the optimally timed integration of conscious experiences.

Keywords: perception , oscillations, MEG, brain-body interactions

What does the Fröhlich effect tell us about sensation time?

*Pascal Mamassian[1]

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When an object suddenly appears and starts moving, its initial position is often mislocalized in its direction of motion. In 1923, Friedrich Fröhlich used this effect to measure the "sensation time", i.e. the time between the impact of light on the retina and the corresponding visual sensation. He reasoned that sensation time can be directly inferred from the spatial bias, given the object speed. This reasoning has since been heavily criticised and new interpretations for the Fröhlich effect have been offered, in particular one based on a spatial prediction that extrapolates into the future to compensate for neural delays. Does this mean that the Fröhlich effect is useless to measure sensation time? We addressed this question by manipulating the duration of a moving object from 50 to 300ms. For the same observers in different experiments, we asked them to report the perceived spatial onset of a small moving disc, its perceived offset, its perceived duration, and its perceived speed. To control for possible eccentricity effects, the object rotated along a visible circle centered on the fixation point. This path was divided into two sectors of different colours, half was blue and the other half orange, and the colour boundaries defined reference marks that observed used to report their perceived onset or offset (e.g. "was stimulus onset in the blue or orange sector?"). Surprisingly, we found an "anti-Fröhlich" effect: the perceived spatial onset was before the start of the motion, at a location that the object never occupied. We also found that perceived speed was largely overestimated, and more so for shorter durations. Finally, we did not find any significant bias in perceived offset or perceived duration. Overall, these results are consistent with a global inference of perceived duration, speed, onset and offset locations, all at the same time at the end of the motion. We argue that this delay relative to the object appearance is informative about sensation time.

Keywords: sensation time, Fröhlich effect, motion perception, visual psychophysics

Affective modulation of temporal binding using linguistic stimuli

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Temporal binding (TB)—the perceived shortening of time between a cause (event A) and its effect (event B)—is often associated with voluntary action. This temporal compression is typically stronger when the action is self-generated, making TB a widely used implicit marker of the sense of agency (SoA). Whereas explicit measures of SoA are usually sensitive to outcome valence (positive outcomes yield higher agency ratings than negative ones), implicit measures such as TB have produced less consistent findings. We examined whether emotional valence influences TB using a two-alternative forced-choice (2AFC) interval discrimination task in three experiments, varying the predictability of outcome valence. Emotional words (e.g., "joy," "death," "chair") served as outcomes, categorized as positive, negative, or neutral. Relevant psycholinguistic variables were matched across valence groups using previous normatization studies for Brazilian Portuguese and two online surveys (N = 54). In Experiment 1 (N = 33), agency (active vs. passive) and word valence were fixed within blocks. In Experiment 2 (N = 40), valence was either fixed or varied across trials, depending on the block. Experiment 3 (N = 40) used only trial-wise variation in valence. Across all experiments, generalized linear mixed models (GLMMs) replicated the TB effect: active trials were perceived as more temporally compressed than passive ones. However, outcome valence did not interact with agency in any of the experiments, suggesting no affective modulation of TB. These findings suggest that emotional valence alone may not be sufficient to influence implicit measures of agency, such as TB. Future research should investigate additional factors and methodologies to gain a deeper understanding of how emotion, agency, and time perception interact.

Keywords: Temporal binding, Sense of Agency, temporal cognition, psychophysics, cognitive-affective neuroscience

An investigation of auditory rhythms with a spiking neural network autoencoder

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Here, we present a biologically inspired spiking neural network, or SNN, framework that learns auditory rhythms from acoustic data by exploiting the exact spike timing of spikes. Although classic deep learning models have been applied to investigate temporal sequences, spiking NNs more accurately reflect the temporal dynamics of biological neural systems.

We first encoded acoustic waveforms containing rhythmic information into spike trains and considered a subcortical model of the peripheral auditory pathway [1.] This model reproduces cochlear transduction and auditory-nerve firing across characteristic frequencies, yielding parallel streams of precisely timed spikes that retain the temporal structure of the input. These spike trains were then used to train a purely spike-based autoencoder. In this framework, the encoder compresses input data into a latent representation, i.e. a simplified representation that captures underlying features of the data, while the decoder reconstructs the amplitude envelope of the original sound, preserving rhythmic features.

By training on isochronous sequences, where consecutive onsets were separated by identical intervals, we demonstrate that rhythmic structure is preserved in the latent space representation. Moreover, the network develops predictive behaviour, by anticipating subsequent beat onsets even in the absence of a beat. This sensitivity reflects a form of temporal expectation embedded in the SNN. To evaluate how the network internalises rhythmic structures, we tested it with sequences that missed beats and inspected the resulting latent representations. By analysing the spiking activity and internal variables within this hidden layer, we revealed how the model encodes temporal regularities and reconstructs the expected onset pattern, in a way that would not be possible in a non-spiking neural network.

1. Zuk, N., Carney, L., Lalor, E. 2018. Preferred Tempo and Low-Audio-Frequency Bias Emerge From Simulated Sub–cortical Processing of Sounds With a Musical Beat. *Front. Neurosci.*, *12*.

Keywords: Spiking Neural Networks, Auditory Processing, Rhythm Processing

Oral | Computational Modeling, Neural Mechanisms

Sat. Oct 18, 2025 9:00 AM - 10:30 AM JST | Sat. Oct 18, 2025 12:00 AM - 1:30 AM UTC Room 2(West B1)

[O5] Oral 5: Computational Modeling, Neural Mechanisms

Chair:Assaf Breska(Max-Planck Institute for Biological Cybernetics)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[O5-01]

Centralized mechanisms of explicit and implicit timing in the human cerebellum: a neuropsychological approach

*Chiara Zanonato[1,2], Richard Ivry[3,4], Assaf Breska[1,3] (1. Max-Planck-Institute for Biological Cybernetics, Tübingen (Germany), 2. University of Tübingen (Germany), 3. Department of Psychology, University of California, Berkeley, CA (United States of America), 4. Helen Willis Neuroscience Institute, University of California, Berkeley, CA (United States of America))

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[O5-02]

Unique Effect of Entrainment on Perception? Context-Specific Temporal Prediction Mechanisms in Multiple Aspects of Perception

*Christina Bruckmann[1,2], Assaf Breska[1] (1. Max Planck Institute for Biological Cybernetics (Germany), 2. University of Tübingen (Germany))

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[O5-03]

Rationalizing temporal decision making and the neural representation of time

*Marshall G Hussain Shuler[1,2] (1. Johns Hopkins (United States of America), 2. Kavli Neuroscience Discovery Institute (United States of America))

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[O5-04]

A Methodology to Accelerate Our Information Processing Toward Revealing the Relation between Process Speed and Time Perception

*Oki Hasegawa[1], Shohei Hidaka[1] (1. Japan Advanced Institute of Science and Technology (Japan))

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[O5-05]

Sensory Reliability Shapes Sequential Effects in Human Duration Perception

*Taku Otsuka[1,2], Joost de Jong[1,3], Wouter Kruijne[1], Hedderik van Rijn[1] (1. University of Groningen (Netherlands), 2. The University of Tokyo (Japan), 3. Université de Paris (France))

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[O5-06]

Bach and Bayes: Prediction in Noisy Musical Sequences

*Akanksha Gupta[1], Alejandro Tabas[2,3] (1. INS, INSERM, Aix-Marseille University, Marseille (France), 2. Perceptual Inference Group, Basque Center on Cognition, Brain and Language, San Sebastian (Spain), 3. Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig (Germany))

Centralized mechanisms of explicit and implicit timing in the human cerebellum: a neuropsychological approach

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Humans keep track of temporal intervals for various purposes, ranging from explicitly reporting perceived durations to implicitly orienting attention in time. Whether shared or segregated timing mechanisms subserve these timing processes is a key neuroscientific question. While neuroimaging studies revealed task-dependent functional dissociations, mostly at the cortical level, recent behavioral work hints at potential computational overlap. Moreover, separate lines of research have implicated the cerebellum in both explicit and implicit interval timing, but whether this reflects one shared or two task-specific cerebellar circuits is unknown. Here, we investigated how the cerebellum might act as a central timing circuit in implicit and explicit interval timing. Cerebellar Ataxia (CA) patients (N=18) and age-matched neurotypical controls (N=16) performed explicit (temporal discrimination) and implicit (cued temporal orienting for speeded detection) interval timing tasks, as well as a control task to account for non-temporal factors. Two intervals (S1, S2) were sequentially presented: S1 was either short (700ms) or long (1200ms), while S2 spanned between the short and long S1. CA patients' performance was impaired compared to healthy controls in both tasks, showing lower temporal sensitivity in temporal discrimination and smaller validity effect in temporal orienting, in line with previous studies. Critically, the performance in the two tasks was more strongly associated in the patient than the control group, with only the former showing a significant correlation, as predicted by a shared process model. Moreover, this was not explained by non-temporal factors. These findings establish the cerebellum as a central sub-second interval timing hub, causally involved in timing intervals independently of the final purpose.

Keywords: explicit timing, implicit timing, interval timing, cerebellum, cerebellar ataxia

Unique Effect of Entrainment on Perception? Context-Specific Temporal Prediction Mechanisms in Multiple Aspects of Perception

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Temporal prediction and preparation are essential for adaptive behavior, and can be generated based on various temporal regularities, including rhythms and interval memory. In rhythmic streams temporal predictions are thought to uniquely rely on phase-aligning neural oscillations to the external rhythm. However, in motor tasks, previous studies found similar behavioral benefits and neural phase alignment patterns for rhythm- and interval-based temporal predictions, questioning the unique role of entrainment in these phenomena. Yet, if rhythmic entrainment acts at low-level sensory circuits, its unique effect might only be revealed under high perceptual load. Here we address this using a challenging perceptual discrimination task, in which visual target timing is either non-predictable, is on-beat with a preceding rhythm (~1.11 Hz), or matches a previously presented interval (900 ms). Examining the differential effect of temporal expectation on multiple levels of perception, we collect both objective classification accuracy and subjective visibility reports, a fundamental distinction in consciousness research that has been overlooked in the temporal attention literature. In line with previous findings, both interval- and rhythm-based temporal expectations improve performance compared to the irregular stream, but to a similar degree, which is inconsistent with the idea that rhythmic entrainment provides a unique perceptual benefit beyond temporal prediction. In EEG, we critically found similar increases in occipital delta phase alignment in the rhythm and interval conditions. This was not found in central channels, demonstrating the independence of sensory from high-level phase alignment. Taken together, these results show that phase alignment can occur in the absence of oscillatory entrainment and call into question whether rhythmic entrainment provides perceptual benefits beyond what would be expected by temporal prediction alone.

Keywords: temporal attention, rhythmic entrainment, interval, EEG, visual discrimination

Rationalizing temporal decision making and the neural representation of time

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By what neural means do we represent the passage and structuring of time and decide how to spend time? How do these representations of value and time relate to evolutionary pressure to maximize reward accumulation? To address these questions, we evaluate whether the temporal difference reinforcement learning (TDRL) algorithm can rationalize temporal decision-making. First, we derive the *optimal solution* for reward accumulation and demonstrate that TDRL's value estimates—infinite sums of exponentially discounted future rewards—systematically deviate from this optimum. Then we show how TDRL, operating over a time state-space representation using regular intervals, fails to learn values that rationalize the curious pattern of decision-making errors exhibited by humans and animals. Our insight, however, is that this failure can be best mitigated by representing time using a time-dilating state-space, wherein the amount of time spent in a subsequent state increases by a precise proportion. TDRL applied to such a time-dilating state-space then learns values that rationalize the diverse suboptimalities observed over decades of investigating how animals and humans decide to spend time. Specifically, it affords optimal forgo behavior, minimizes a suboptimal bias toward sooner-smaller rewards in mutually exclusive choices, and leads to a suboptimal unwillingness to abandon engaged pursuits (sunk cost). In proposing PARSUIT theory (Pursuit-based Atomized Reinforcement of State-value Using Increasing Timesteps), we provide 1) a general, mechanistically descriptive explanation of temporal decision making, 2) a normative rationalization for why time takes the neural form that it does, and 3) advance TDRL as the learning algorithm used in temporal decision-making.

Keywords: Temporal Difference Reinforcement Learning, reward-rate maximization, dilating time state-space, temporal decision-making

A Methodology to Accelerate Our Information Processing Toward Revealing the Relation between Process Speed and Time Perception

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The subjective experience of time slowing down during peak performance, or 'flow', suggests a link between cognitive processing speed and time perception. However, this relationship is not well understood due to the limitations of short-duration tasks, which are typically employed in psychological and neurological laboratory studies. This is a critical limitation, as the phenomena of interest typically emerge during continuous, sustained activities in the real world. Therefore, to properly test our central hypothesis—an extension of Treisman’ s internal clock model which posits that a high-arousal state accelerates an internal pacemaker to simultaneously improve information processing speed and extend subjective time —an experimental paradigm capable of inducing and continuously sustaining such a state is first necessary. Here, we present this paradigm, which involves an adaptive Tetris game designed to induce a flow-like state and enable a continuous study of the aforementioned link. The system uses a Markov process model to estimate players' abilities and adjust the task's difficulty in real time. To validate this approach, we first measured baseline performance in an ideal, untimed version of the task, confirming that player performance fell within the range predicted by our model. We then investigated the effect of three patterns of difficulty change —linear increase, linear decrease and random —on processing speed (lines cleared per minute). Although players achieved a similar maximum performance level at the end of the game in all conditions, performance improved most quickly under the linearly increasing difficulty condition. These results demonstrate that an adaptive challenge that continuously and predictably increases in response to a player's ability is a key factor for accelerating cognitive processing. At this conference, we will report on the preliminary performance evaluation of the developed task system.

Keywords: Flow State, Infomation Processing Speed

Sensory Reliability Shapes Sequential Effects in Human Duration Perception

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Perceived durations are biased towards immediately preceding percepts. Although such sequential effects in time perception have long been recognized, the Bayesian framework has recently emerged as a compelling account of these phenomena. Crucially, while the Bayesian framework posits that the magnitude of the sequential effect depends on the reliability of both the previous and current stimuli, empirical support for this prediction remains lacking. In order to test this central prediction of the Bayesian framework, we systematically manipulated the perceptual noise of to-be timed stimuli by embedding them in dynamic visual noise. We found that reproduced durations were biased towards the duration of the preceding stimulus, confirming the presence of a sequential effect. Importantly, the magnitude of this effect was modulated by the reliability of both the previous and current stimuli, in a manner consistent with Bayesian predictions. Furthermore, by fitting a Bayesian computational model that updated prior expectations on a trial-by-trial basis, we demonstrated that manipulating the uncertainty of the current sensory input (likelihood variance) enabled the model to capture the observed reliability-dependent modulation of the sequential effect. These findings provide direct empirical evidence for reliability-based integration in human duration judgements and highlight the sequential effect as an adaptive mechanism that dynamically adjusts to sensory uncertainty.

Keywords: sequential effect, Bayesian modeling, duration reproduction, sensory reliability

Bach and Bayes: Prediction in Noisy Musical Sequences

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Information from the external environment is often uncertain and ambiguous, posing a challenge for the brain to accurately infer the state of the world. According to the predictive processing framework, prior knowledge pertinent to inference is compressed into predictions about imminent future states. These predictions are combined with sensory inputs using Bayesian belief updating. While this approach is optimal for inferring latent states in certain stochastic systems, it may not be useful when applied to more complex systems such as music or language. In this work, we examine whether neural networks trained to infer the current latent state in a musical sequence also develop a capacity to predict what comes next.

To investigate this hypothesis, we utilized tokenized Bach compositions corrupted with noise as sensory inputs and gated recurrent neural networks (GRUs) to model neural circuits. The training procedure involved two stages: first, to infer the current token, and then, to optimize a linear readout for predictions of the next token to see if the predictions are encoded in the network's internal states. Furthermore, we benchmarked the network’ s performance against an optimal Markovian model, which predicts the next token using only the current token. Our findings demonstrate that neural circuits fine-tuned for perceiving the current state can learn to predict future sensory input, suggesting that predictive capabilities emerge as a consequence of such optimization. This evidence strengthens the computational foundation of the predictive coding framework and offers insights into how biological systems may utilize prior knowledge to adaptively operate within uncertain environments.

Keywords: Predictive Processing, Bayesian Brain Hypothesis, Recurrent Neural Networks (RNNs), gated recurrent neural networks (GRUs)