Sun. Oct 19, 2025

Oral | Language, Animal

Sun. Oct 19, 2025 10:45 AM - 12:15 PM JST | Sun. Oct 19, 2025 1:45 AM - 3:15 AM UTC Room 3(East B1)

[O8] Oral 8: Language, Animal

Chair:Hiroki Koda(The University of Tokyo)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[O8-01]

Towards Differentiating Endogenously and Exogenously Driven Rhythms in the Brain: Syntax, Prosody and Delta-Band Activity

*Leonardo Zeine[1,2], Peter Donhauser[1], David Poeppel[3] (1. Ernst Strüngmann Institute for Neuroscience (Germany), 2. Max Planck School of Cognition (Germany), 3. New York University (United States of America))

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[O8-02]

Reversible inactivation of insular and prelimbic cortices in a temporal decision-making task in rats

*Marcelo S Caetano[1], Estela B Nepomoceno[2] (1. Universidade Federal do ABC (UFABC) (Brazil), 2. Universidade São Caetano do Sul (USCS) (Brazil))

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[O8-03]

Temporal Strategies and Cue Integration in Rats: Evidence from Operant and T-Maze Midsession Reversal Tasks

*Marcelo Bussotti Reyes[1], Marcelo Salvador Caetano[1], Armando Machado[2] (1. Universidade Federal do ABC (Brazil), 2. University of Aveiro (Portugal))

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[O8-04]

Implicit timing in a group of freely behaving Guinea baboons

*Jennifer T Coull[1], Nicolas Claidière[1,2], Adrien Meguerditchian[1,2], Siham Bouziane[1] (1. Centre for Research in Psychology & Neurosciences, CNRS & Aix-Marseille University (France), 2. Station de Primatologie-Celphedia, UAR846, CNRS, Rousset (France))

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[O8-05]

Spontaneous temporal predictions in Guinea Baboons: Insights from a sequential variable foreperiod paradigm

*Siham Bouziane[1], Adrien Meguerditchian[1,2], Nicolas Claidière[1,2], Jennifer T Coull[1] (1. Centre de Recherche en Psychologie et Neurosciences (France), 2. Station de Primatologie-Celphedia UAR846 CNRS - Rousset France (France))

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[O8-06]

An evolutionary model of vocal accelerando in African penguins

*Yannick Jadoul[1,2,3], Taylor A. Hersh[2,4], Elias Fernández Domingos [3,5], Marco Gamba[6], Livio Favaro[6], Andrea Ravignani[1,2,7,8] (1. Department of Human Neurosciences, Sapienza University of Rome, Rome (Italy), 2. Comparative Bioacoustics Group, Max Planck Institute for Psycholinguistics, Nijmegen (Netherlands), 3. Artificial

Intelligence Lab, Vrije Universiteit Brussel, Brussels (Belgium), 4. Marine Mammal Institute, Oregon State University, Newport, Oregon (United States of America), 5. Machine Learning Group, Université Libre de Bruxelles, Brussels (Belgium), 6. Department of Life Sciences and Systems Biology, University of Turin, Turin (Italy), 7. Center for Music in the Brain, Department of Clinical Medicine, Aarhus University, Aarhus (Denmark), 8. Research Center of Neuroscience “CRiN-Daniel Bovet”, Sapienza University of Rome, Rome (Italy))

Oral | Motor, Music

Sun. Oct 19, 2025 9:00 AM - 10:30 AM JST | Sun. Oct 19, 2025 12:00 AM - 1:30 AM UTC Room 2(West B1)

[O7] Oral 7: Motor, Music

Chair:Ségolène M. R. Guérin(Université du Littoral Côte d'Opale)

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

[O7-01]

Phase-dependent encoding of motor memory

*Yuto Makino[1], Masaya Hirashima[1] (1. National Institute of Information and Communications Technology (Japan))

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

[O7-02]

Mapping Time and Space in Social Interactions with the Mirror and Rock-Paper-Scissor Games

*Julia Ayache[1,2], Marta Bieńkiewicz[2], Simon Pla[2], Pierre Jean[2], Alexander Sumich[1,3], Nadja Heym[1], Benoit G. Bardy[2] (1. NTU Psychology, Nottingham Trent University, Nottingham (UK), 2. EuroMov Digital Health in Motion, Univ. Montpellier IMT Mines Alès, Montpellier (France), 3. Department of Psychology, Auckland University of Technology, Auckland (New Zealand))

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

[O7-03]

Sharing Timing in Physical and Virtual Spaces

*Julien Laroche[1], Julia Ayache[1], Marco Coraggio[2], Angelo di Porzio[2], Francesco de Lellis[3], Anna Katharina Hebborn[4], Andreas Panayiotou[5], Lyam Pepin[6], Panayiotis Charalambous[5], Simon Pla[1], Pierre Jean[1], Mario di Bernardo[2,3], Didier Stricker[4], Benoît Bardy[1] (1. EuroMov DHM, Univ. Montpellier, IMT Alès (France), 2. Scuola Superiore Meridionale (Italy), 3. Univ. Napoli "Federico II" (Italy), 4. German Research Center for Artificial Intelligence (Germany), 5. CYENS (Cyprus), 6. Univ. Paul Valery Montpellier, (France))

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

[O7-04]

Juggling on the Moon: Adaptation of complex motor skills to simulated low-gravity enabled changes in tempo

*John Rehner Iversen[1], Akilesh Sathyakumar[1], Hyeonseok Kim[2], Makoto Miyakoshi[2], Wanhee Cho[3], Hirokazu Tanaka[4], Takahiro Kagawa[5], Makoto Sato[3], Scott Makeig[7], Hiroyuki Kambara[6], Natsue Yoshimura[3] (1. McMaster University (Canada), 2. Cincinnati Children's Hospital Medical Center (United States of America), 3. Institute of Science Tokyo (Japan), 4. Tokyo City University (Japan), 5. Aichi Institute of Technology (Japan), 6. Tokyo Polytechnic University (Japan), 7. University of California San Diego (United States of America))

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

[O7-05]

Culture-Driven Plasticity and Imprints of Body-Movement Pace on Musical Rhythm Processing

*Ségolène M. R. Guérin[1,2], Emmanuel Coulon[2], Tomas Lenc[2,3], Rainer Polak[4], Peter Keller[5], Laurie Gallant[2], Antoine Boveroux[2], Sylvie Nozaradan[2] (1. URePSSS, Université du Littoral Côte d'Opale (France), 2. Institute of Neuroscience (IoNS), Université Catholique de Louvain (UCLouvain) (Belgium), 3. Basque Center on Cognition, Brain, and Language (BCBL) (Spain), 4. RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion, University of Oslo (Norway), 5. Center for Music in the Brain, Department of Clinical Medicine, Aarhus University & The Royal Academy of Music Aarhus/Aalborg (Denmark))

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

[O7-06]

Evidence for neural categorization of rhythm in human newborns

*Francesca M. Barbero[1], Tomas Lenc[1,2], Alban Gallard[3], Nori Jacoby[4,5], Rainer Polak[6,7], Arthur Foulon[3], Sahar Moghimi[3], Sylvie Nozaradan[1,8] (1. Institute of Neuroscience (IoNS), University of Louvain (UCLouvain), 1348 Louvain-la-Neuve (Belgium), 2. Basque Center on Cognition, Brain and Language (BCBL), Donostia-San Sebastian (Spain), 3. Groupe de Recherches sur l'Analyse Multimodale de la Fonction Cérébrale (GRAMFC, Inserm UMR1105), Université de Picardie, 80054 Amiens (France), 4. Computational Auditory Perception Group, Max Planck Institute for Empirical Aesthetics, Grüneburgweg 14, 60322 Frankfurt am Main (Germany), 5. Department of Psychology, Cornell University, Ithaca, NY 14853 (United States of America), 6. RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion, University of Oslo (Norway), 7. Department of Musicology, University of Oslo (Norway), 8. International Laboratory for Brain, Music and Sound Research (BRAMS), Montreal (Canada))

Oral | Timing & Time Perception

Sun. Oct 19, 2025 10:45 AM - 12:15 PM JST | Sun. Oct 19, 2025 1:45 AM - 3:15 AM UTC Room 2(West B1)

[O9] Oral 9: Timing & Time Perception

Chair:Sae Kaneko(Hokkaido University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[O9-01]

How each heartbeat shapes neural processing of duration?

*Irena Arslanova[1], Magda Jaglinska[2], Manos Tsakiris[1] (1. Royal Holloway University of London (UK), 2. University College London (UK))

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[O9-02]

Mechanisms of Time Perception: Roles of Time-Frequency Power and Cross-Frequency Coupling

*Tereza Nekovarova[1,2], Veronika Rudolfova[1,2], Kristyna Maleninska[1], Ondrej Skrla[1], Jakub Svoboda[1], Jana Koprivova[1,3], Martin Brunovsky[1,3], Vlastimil Koudelka[1] (1. National Institute of Mental Health (Czech Republic), 2. Faculty of Natural Science, Charles University (Czech Republic), 3. 3rd Faculty of Medicine (Czech Republic))

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[O9-03]

Intra- and inter-individual variability in body-brain-behavioral rhythms: a multimodal study with smart wearables

*Antonio Criscuolo[1], Michael Schwartze[1], Sonja Kotz[1,2] (1. Maastricht University (Netherlands), 2. Max Planck Institute for Human Cognitive and Brain Sciences (Germany))

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[O9-04]

Ontogeny of rhythmic performances and contribution of motor and perceptual rhythmic preferences

*Pier-Alexandre Rioux[1], Nicola Thibault[1,2], Daniel Fortin-Guichard[3], Émilie Cloutier-Debaque[4], Simon Grondin[1] (1. Laval University (Canada), 2. CERVO, Brain Research Center (Canada), 3. McGill University (Canada), 4. University of Montreal Hospital Center (Canada))

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[O9-05]

Representational dynamics of subjective duration in the human brain

*Camille L. Grasso[1], Ladislas Nalborczyk[2], Virginie van Wassenhove[1] (1. CEA/DRF/Inst. Joliot, NeuroSpin; INSERM, Cognitive Neuroimaging Unit; Université Paris-Saclay, Gif/Yvette, 91191 France (France), 2. Aix Marseille University, CNRS, LPL (France))

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[O9-06]

Mouse Strain Differences in Time Estimation are Related to Impulsive Behavior

*MARIELENA EUDAVE-PATIÑO[1], JONATHAN BURITICÁ[2], JAIME EMMANUEL ALCALÁ TEMORES [2] (1. UNIVERSIDAD AUTÓNOMA DE AGUASCALIENTES (Mexico), 2. UNIVERSIDAD DE GUADALAJARA (Mexico))

Oral | EEG, MRI, TMS

Sun. Oct 19, 2025 1:00 PM - 2:30 PM JST | Sun. Oct 19, 2025 4:00 AM - 5:30 AM UTC Room 3(East B1)

[O10] Oral 10: EEG, MRI, TMS

Chair:Masamichi J Hayashi(Center for Information and Neural Networks (CiNet))

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

[O10-01]

Common EEG connectivity patterns between time reproduction and working memory

*Sergio Rivera-Tello[1], Julieta Ramos-Loyo[1] (1. University of Guadalajara (Mexico))

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

[O10-02]

Perception of short, but not long, time intervals is modality-specific: Converging electroencephalography evidence from vibrotactile and auditory modalities

*Nicola Thibault[1,2], Pier-Alexandre Rioux[1], Andréanne Sharp[1,2], Philippe Albouy[1,2,3], Simon Grondin[1] (1. Université Laval (Canada), 2. CERVO Brain Research Centre (Canada), 3. International Laboratory for Brain (Canada))

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

[O10-03]

Orthogonal Codes for Time and Decision in Human Temporal Perception

*Andre Mascioli Cravo[1], Mateus Silvestrin[3], Peter Maurice Erna Claessens[1], Nicholas Myers[2] (1. Universidade Federal do ABC (UFABC) (Brazil), 2. School of Psychology, University of Nottingham, UK (UK), 3. Federal University of the São Francisco Valley (Brazil))

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

[O10-04]

Shared spectral fingerprints of temporal memory precision and representation of the temporal structure of complex narratives

*Matteo Frisoni[1], Pierpaolo Croce[2], Annalisa Tosoni[2], Filippo Zappasodi[2], Carlo Sestieri[2] (1. University of Bologna (Italy), 2. University D'Annunzio Chieti Pescara (Italy))

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

[O10-05]

Defining a functional hierarchy of millisecond time: from visual stimulus processing to duration perception

*Valeria Centanino[1], Gianfranco Fortunato[1], Domenica Bueti[1] (1. International School for Advanced Studies (SISSA) (Italy))

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

[O10-06]

The chronometry of time processing in visual and premotor areas

*Domenica Bueti[1] (1. International School for Advanced Studies (SISSA) (Italy))

Oral | Language, Animal

Sun. Oct 19, 2025 10:45 AM - 12:15 PM JST | Sun. Oct 19, 2025 1:45 AM - 3:15 AM UTC Room 3(East B1)

[O8] Oral 8: Language, Animal

Chair:Hiroki Koda(The University of Tokyo)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[O8-01]

Towards Differentiating Endogenously and Exogenously Driven Rhythms in the Brain: Syntax, Prosody and Delta-Band Activity

*Leonardo Zeine[1,2], Peter Donhauser[1], David Poeppel[3] (1. Ernst Strüngmann Institute for Neuroscience (Germany), 2. Max Planck School of Cognition (Germany), 3. New York University (United States of America))

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[O8-02]

Reversible inactivation of insular and prelimbic cortices in a temporal decision-making task in rats

*Marcelo S Caetano[1], Estela B Nepomoceno[2] (1. Universidade Federal do ABC (UFABC) (Brazil), 2. Universidade São Caetano do Sul (USCS) (Brazil))

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[O8-03]

Temporal Strategies and Cue Integration in Rats: Evidence from Operant and T-Maze Midsession Reversal Tasks

*Marcelo Bussotti Reyes[1], Marcelo Salvador Caetano[1], Armando Machado[2] (1. Universidade Federal do ABC (Brazil), 2. University of Aveiro (Portugal))

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[O8-04]

Implicit timing in a group of freely behaving Guinea baboons

*Jennifer T Coull[1], Nicolas Claidière[1,2], Adrien Meguerditchian[1,2], Siham Bouziane[1] (1. Centre for Research in Psychology & Neurosciences, CNRS & Aix-Marseille University (France), 2. Station de Primatologie-Celphedia, UAR846, CNRS, Rousset (France))

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[O8-05]

Spontaneous temporal predictions in Guinea Baboons: Insights from a sequential variable foreperiod paradigm

*Siham Bouziane[1], Adrien Meguerditchian[1,2], Nicolas Claidière[1,2], Jennifer T Coull[1] (1. Centre de Recherche en Psychologie et Neurosciences (France), 2. Station de Primatologie-Celphedia UAR846 CNRS - Rousset France (France))

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[O8-06]

An evolutionary model of vocal accelerando in African penguins

*Yannick Jadoul[1,2,3], Taylor A. Hersh[2,4], Elias Fernández Domingos [3,5], Marco Gamba[6], Livio Favaro[6], Andrea Ravignani[1,2,7,8] (1. Department of Human Neurosciences, Sapienza University of Rome, Rome (Italy), 2. Comparative Bioacoustics Group, Max Planck Institute for Psycholinguistics, Nijmegen (Netherlands), 3. Artificial Intelligence Lab, Vrije Universiteit

Brussel, Brussels (Belgium), 4. Marine Mammal Institute, Oregon State University, Newport, Oregon (United States of America), 5. Machine Learning Group, Université Libre de Bruxelles, Brussels (Belgium), 6. Department of Life Sciences and Systems Biology, University of Turin, Turin (Italy), 7. Center for Music in the Brain, Department of Clinical Medicine, Aarhus University, Aarhus (Denmark), 8. Research Center of Neuroscience “CRiN-Daniel Bovet”, Sapienza University of Rome, Rome (Italy))

Towards Differentiating Endogenously and Exogenously Driven Rhythms in the Brain: Syntax, Prosody and Delta-Band Activity

*Leonardo Zeine[1,2], Peter Donhauser[1], David Poeppel[3]

1. Ernst Strüngmann Institute for Neuroscience, 2. Max Planck School of Cognition, 3. New York University

During speech processing, the brain tracks acoustic fluctuations across multiple timescales. In the context of neural oscillations for language perception, theta-band activity (4–8 Hz) is argued to phase-lock with the occurrences of syllables, and delta-band activity (<3 Hz), with syntactic and/or prosodic events—a claim that has sparked intense debate in the field (Kazanina & Tavano, 2024). On one hand, syntax and prosody are naturally intertwined; on the other, delta-band activity is both widespread across the brain and sensitive to low-level acoustic features such as onsets.Here, we introduce a novel data-driven method to disentangle sentence-internal from boundary (onset/offset) activity. Our approach consists of two consecutive sets of spatial filters: the first, a denoiser, that captures language-related activity, and the second, a functional filter, that isolates sentence-internal responses.By analyzing an open dataset of source-localized MEG recordings from 140 participants (Schoffelen et al., 2019) who listened to sentences in Dutch, we identified two distinct timescales of sentence-internal activity: one, predominantly delta-band, in the right superior temporal gyrus (STG); and another in both delta and theta bands in the left STG. Both components exhibited higher phase clustering in the delta-band around strong prosodic boundaries compared to weak boundaries and random timepoints.We also identified two distinct onset/offset-related components: one sustained (bilateral) and another transient (right-lateralized), neither modulated by prosodic or syntactic representations. We argue that they reflect low-level acoustic responses typically conflated with endogenously driven responses in conventional sensor-space analysis. Altogether, our findings offer a comprehensive characterization of key temporal profiles in speech processing, and point to delta-band phase-locking as a candidate mechanism for integration of prosodic information.

Keywords: Syntax, Prosody, Delta-band oscilaltions, Spatial filtering

Reversible inactivation of insular and prelimbic cortices in a temporal decision-making task in rats

*Marcelo S Caetano[1], Estela B Nepomoceno[2]

1. Universidade Federal do ABC (UFABC), 2. Universidade São Caetano do Sul (USCS)

The anterior insular cortex (AIC), an area of sensory integration, detects salient events to guide goal-directed behavior, track errors, and estimate the passage of time. Projections between the AIC and medial prefrontal cortex (mPFC) are found both in rats and humans, and suggest a possible role for these structures in the integration of autonomic responses during ongoing behavior. Few studies, however, have investigated the role of AIC and mPFC in decision-making and time estimation tasks. Here, we employed bilateral inactivations to describe the role of AIC and mPFC in a temporal decision-making task in rats. In this task (the "switch task"), rats are placed in a standard operant chamber with two levers. In some trials, presses on one of the levers will lead to reinforcement after a short interval (3 s). In other trials, a press on the other lever will lead to reinforcement after a long interval (6 s). Since short and long trials are randomly presented (i.e., unpredictable), optimal performance requires a switch from the short to the long lever after the short fixed interval elapses and no reinforcement is delivered. In a first experiment, we showed that successful switch from the short to the long lever was dependent on AIC and mPFC. During AIC inactivation, switch latencies became more variable; and during mPFC inactivation switch latencies became both more variable and less accurate. In a follow-up experiment, we manipulated the probabilities associated with the occurrence of a short or a long trial, and observed that the animals were sensitive to changes in these probabilities, adjusting switch latencies in order to maximize reinforcement. These findings point to a dissociation between AIC and mPFC in temporal decision-making, and contribute to the understanding of the neural substrates involved in the encoding of uncertainty as a function of time.

Keywords: Decision-making, Timing, Probability estimation, Switch task, Muscimol

Temporal Strategies and Cue Integration in Rats: Evidence from Operant and T-Maze Midsession Reversal Tasks

*Marcelo Bussotti Reyes[1], Marcelo Salvador Caetano[1], Armando Machado[2]

1. Universidade Federal do ABC, 2. University of Aveiro

The midsession reversal (MSR) task assesses cognitive flexibility by requiring animals to switch from one correct choice (S1) to another (S2) halfway through a session, without any explicit cue signaling the change. Although the task includes no formal timing component, species such as pigeons and starlings rely heavily on temporal cues, often committing anticipatory or perseverative errors. In contrast, monkeys and humans typically adopt the optimal win-stay/lose-shift (WSLS) strategy, shifting behavior only after the first error. In rats, the strategy depends on the experimental context: in T-mazes, they tend to rely on timing, whereas in operant chambers, behavior is often dominated by WSLS, with little evidence of timing during training. Here, we directly tested the temporal hypothesis in rats using both paradigms. In the operant task, rats learned to discriminate between steady and flickering lights, always presented on the same side, with the reinforced stimulus reversing midway through each session. During training —and consistent with prior studies— rats showed no anticipation of the reversal, relying instead on WSLS. However, when we manipulated the intertrial interval (ITI), rats adjusted their responses according to elapsed time, indicating that timing can guide behavior when the task’s temporal structure is altered. In the T-maze version, rats relied on temporal cues already during training, committing both anticipatory and perseverative errors. When the ITI was manipulated, rats adopted a mixed strategy, combining timing (primarily) and trial counting. These findings demonstrate that rats flexibly integrate multiple cues depending on task dynamics, challenging the notion that they rely solely on reinforcement history in operant chambers or exclusively on timing in spatial tasks.

Keywords: reversal learning, cognitive flexibility, decision-making, strategy use

Implicit timing in a group of freely behaving Guinea baboons

*Jennifer T Coull[1], Nicolas Claidière[1,2], Adrien Meguerditchian[1,2], Siham Bouziane[1]

1. Centre for Research in Psychology & Neurosciences, CNRS & Aix-Marseille University, 2. Station de Primatologie-Celphedia, UAR846, CNRS, Rousset

We gradually develop our sense of time through experience. It helps us predict when events will occur, allowing us to direct attention and adapt behavior accordingly. Yet even though all living beings need to make temporal predictions to survive, our understanding of the evolutionary origins of such a capacity is relatively unknown. Here we used free-access operant conditioning devices to investigate temporal predictions in 15 freely behaving captive Guinea baboons. In two separate experiments, individuals were trained to optimize their response timing by touching a target that appeared after a fixed foreperiod (FP) of either 600ms or 300ms. During the testing phase, the FP was either the trained ("standard") FP (60% of trials) or was randomly selected from one of six equiprobable shorter or longer intervals (30% of trials). In the remaining 10%, the target was absent (catch trials). Results revealed a U-shaped profile of performance with RTs being fastest for the most probable FP, getting gradually slower for increasingly shorter or longer FPs. Crucially, this pattern was observed even though all non-standard FPs were equiprobable, indicating that the metrical properties of FP duration had been implicitly integrated into baboons' performance. In addition, during the longer FP trials, baboons often responded before the target even appeared. Since most of these anticipatory responses occurred around the time of the standard FP and were produced in the absence of an external stimulus, these data suggest FP probabilities had been internalized into a temporal expectation for the standard FP. Our results demonstrate, for the first time in such a large group of non-human primates, that baboons use statistical learning of temporal probabilities to implicitly form expectations about event timing, which helps them optimize behavior. These findings contribute to the growing body of evidence suggesting that predictive timing abilities may be widespread across the primate lineage and beyond.

Keywords: temporal prediction, temporal expectation, foreperiod, statistical learning, non-human primates, ethology

Spontaneous temporal predictions in Guinea Baboons: Insights from a sequential variable foreperiod paradigm

*Siham Bouziane[1], Adrien Meguerditchian[1,2], Nicolas Claidière[1,2], Jennifer T Coull[1]

1. Centre de Recherche en Psychologie et Neurosciences, 2. Station de Primatologie-Celphedia UAR846 CNRS - Rousset France

Predicting the arrival time of an event is key to navigating our environment. Previous research on temporal predictions in non-human primates (NHPs) has primarily taken place in laboratory settings, limiting both natural engagement and sample size. Here, we adopt a naturalistic approach by studying temporal prediction in a group of 20 captive Guinea baboons, using free-access operant conditioning devices that allow for voluntary participation in cognitive tasks.In two separate studies, baboons performed a simple reaction time (RT) task in which four visual targets appeared sequentially after either regular (500 ms) or irregular (300-700ms) foreperiods (FP). In both studies, the target was more likely to appear after the “standard” 500ms FP than any of the others. Importantly, baboons were free to choose their own response speed and were not rewarded for particularly fast RTs. Nevertheless, we found significant effects of FP probability on RT. First, RTs were globally faster for temporally regular sequences than irregular sequences, indicating that the temporal predictability of the sequence speeded performance. Second, within the irregular sequences, RTs were faster for targets appearing after longer FPs, indicating an influence of the hazard function. Nevertheless, an asymmetric sequential effect revealed that RTs were also influenced by the FP of the previous target, indicating an effect of temporal trial history on performance. RTs were slower when the current FP was shorter, rather than longer, than the previous one. Most importantly, this effect varied as a function of the signed temporal difference (deltaFP) between FPs on successive trials ($FP_{current}$ - $FP_{previous}$). RTs were progressively slower as deltaFP decreased, indicating an influence of FP magnitude on performance. Finally, individual differences in performance indicated statistical learning of the most common 500ms FP, demonstrating that some baboons were sensitive to more global temporal probabilities. Our results demonstrate, for the first time in such a large group of NHPs, that baboons spontaneously use temporally predictable information to optimise performance, despite never having been trained to do so, and further informs our understanding of the evolutionary roots of time processing.

Keywords: Implicit Timing, Rhythms, Non-Human Primates, Comparative Psychology, Statistical learning

An evolutionary model of vocal accelerando in African penguins

*Yannick Jadoul[1,2,3], Taylor A. Hersh[2,4], Elias Fernández Domingos [3,5], Marco Gamba[6], Livio Favaro[6], Andrea Ravignani[1,2,7,8]

1. Department of Human Neurosciences, Sapienza University of Rome, Rome, 2. Comparative Bioacoustics Group, Max Planck Institute for Psycholinguistics, Nijmegen, 3. Artificial Intelligence Lab, Vrije Universiteit Brussel, Brussels, 4. Marine Mammal Institute, Oregon State University, Newport, Oregon, 5. Machine Learning Group, Université Libre de Bruxelles, Brussels, 6. Department of Life Sciences and Systems Biology, University of Turin, Turin, 7. Center for Music in the Brain, Department of Clinical Medicine, Aarhus University, Aarhus, 8. Research Center of Neuroscience "CRiN-Daniel Bovet", Sapienza University of Rome, Rome

In animal behavior and communication, regularly-timed movement and sounds are ubiquitous, as many underlying physiological processes generate isochronous sequences of events. When it comes to rhythm and music, however, isochrony is only the simplest building block possible. For example, accelerando is a rhythmic structure which consists of an increasing tempo throughout a temporal sequence, and has been described in a wide range of animal displays. One such display are the ecstatic display songs (EDSs) produced by African penguins. During high arousal breeding seasons, individuals produce these energetically costly, multisyllabic songs. We rhythmically analyzed recordings from 26 male African penguins and found that the vocalizations within an EDS reliably exhibit accelerando and crescendo (i.e., syllables follow each other faster and become louder as an EDS progresses). We modeled the production of these temporal sequences and their interaction and used evolutionary game theory and computer simulations to link two aspects of temporal structure, acceleration and overlap: We tested whether rhythmic accelerando could evolve under a pressure for acoustic overlap in time. Both a mathematical analysis and computational simulations of our model showed that evolutionary pressure for more overlap can indeed cause a population of initially isochronous individuals to evolve the production of sequences with a moderate level of acceleration. Our model and results demonstrate a potential evolutionary trajectory for the emergence of accelerando or other forms of tempo modulation within an initially isochronous population, and suggest new hypotheses to be tested empirically. Future studies combining empirical data and computer models in such a comparative approach can provide further insight into the function and evolutionary pressure at play, here and in other model species, and will boost our understanding of the evolution of rhythm.

Keywords: evolutionary game theory, tempo, animal communication, computer simulations

Oral | Motor, Music

Sun. Oct 19, 2025 9:00 AM - 10:30 AM JST | Sun. Oct 19, 2025 12:00 AM - 1:30 AM UTC Room 2(West B1)

[O7] Oral 7: Motor, Music

Chair:Ségolène M. R. Guérin(Université du Littoral Côte d'Opale)

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

[O7-01]

Phase-dependent encoding of motor memory

*Yuto Makino[1], Masaya Hirashima[1] (1. National Institute of Information and Communications Technology (Japan))

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

[O7-02]

Mapping Time and Space in Social Interactions with the Mirror and Rock-Paper-Scissor Games

*Julia Ayache[1,2], Marta Bieńkiewicz[2], Simon Pla[2], Pierre Jean[2], Alexander Sumich[1,3], Nadja Heym[1], Benoit G. Bardy[2] (1. NTU Psychology, Nottingham Trent University, Nottingham (UK), 2. EuroMov Digital Health in Motion, Univ. Montpellier IMT Mines Alès, Montpellier (France), 3. Department of Psychology, Auckland University of Technology, Auckland (New Zealand))

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

[O7-03]

Sharing Timing in Physical and Virtual Spaces

*Julien Laroche[1], Julia Ayache[1], Marco Coraggio[2], Angelo di Porzio[2], Francesco de Lellis[3], Anna Katharina Hebborn[4], Andreas Panayiotou[5], Lyam Pepin[6], Panayiotis Charalambous[5], Simon Pla[1], Pierre Jean[1], Mario di Bernardo[2,3], Didier Stricker[4], Benoît Bardy[1] (1. EuroMov DHM, Univ. Montpellier, IMT Alès (France), 2. Scuola Superiore Meridionale (Italy), 3. Univ. Napoli "Federico II" (Italy), 4. German Research Center for Artificial Intelligence (Germany), 5. CYENS (Cyprus), 6. Univ. Paul Valery Montpellier, (France))

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

[O7-04]

Juggling on the Moon: Adaptation of complex motor skills to simulated low-gravity enabled changes in tempo

*John Rehner Iversen[1], Akilesh Sathyakumar[1], Hyeonseok Kim[2], Makoto Miyakoshi[2], Wanhee Cho[3], Hirokazu Tanaka[4], Takahiro Kagawa[5], Makoto Sato[3], Scott Makeig[7], Hiroyuki Kambara[6], Natsue Yoshimura[3] (1. McMaster University (Canada), 2. Cincinnati Children's Hospital Medical Center (United States of America), 3. Institute of Science Tokyo (Japan), 4. Tokyo City University (Japan), 5. Aichi Institute of Technology (Japan), 6. Tokyo Polytechnic University (Japan), 7. University of California San Diego (United States of America))

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

[O7-05]

Culture-Driven Plasticity and Imprints of Body-Movement Pace on Musical Rhythm Processing

*Ségolène M. R. Guérin[1,2], Emmanuel Coulon[2], Tomas Lenc[2,3], Rainer Polak[4], Peter Keller[5], Laurie Gallant[2], Antoine Boveroux[2], Sylvie Nozaradan[2] (1. URePSSS, Université du Littoral Côte d'Opale (France), 2. Institute of Neuroscience (IoNS), Université Catholique de Louvain (UCLouvain) (Belgium), 3. Basque Center on Cognition, Brain, and Language (BCBL) (Spain), 4.

RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion, University of Oslo (Norway), 5. Center for Music in the Brain, Department of Clinical Medicine, Aarhus University & The Royal Academy of Music Aarhus/Aalborg (Denmark))

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

[O7-06]

Evidence for neural categorization of rhythm in human newborns

*Francesca M. Barbero[1], Tomas Lenc[1,2], Alban Gallard[3], Nori Jacoby[4,5], Rainer Polak[6,7], Arthur Foulon[3], Sahar Moghimi[3], Sylvie Nozaradan[1,8] (1. Institute of Neuroscience (IoNS), University of Louvain (UCLouvain), 1348 Louvain-la-Neuve (Belgium), 2. Basque Center on Cognition, Brain and Language (BCBL), Donostia-San Sebastian (Spain), 3. Groupe de Recherches sur l'Analyse Multimodale de la Fonction Cérébrale (GRAMFC, Inserm UMR1105), Université de Picardie, 80054 Amiens (France), 4. Computational Auditory Perception Group, Max Planck Institute for Empirical Aesthetics, Grüneburgweg 14, 60322 Frankfurt am Main (Germany), 5. Department of Psychology, Cornell University, Ithaca, NY 14853 (United States of America), 6. RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion, University of Oslo (Norway), 7. Department of Musicology, University of Oslo (Norway), 8. International Laboratory for Brain, Music and Sound Research (BRAMS), Montreal (Canada))

Phase-dependent encoding of motor memory

*Yuto Makino[1], Masaya Hirashima[1]

1. National Institute of Information and Communications Technology

Motor behaviors are highly flexible across temporal and spatial scales. For example, when writing a letter, its geometric pattern is preserved despite variations in scale and speed (Viviani & Terzuolo, 1980). Such flexibility cannot be fully explained by internal representations based on movement states (Sing et al., 2009) or absolute time. Instead, the brain may rely on a more abstract representation that captures the temporal progression relative to its overall structure. Here, we propose the existence of phase-dependent motor primitives, where phase defines the normalized temporal position within a movement. In Experiment 1, participants adapted to an S-shaped force during an 8 cm (or 16 cm) reach, where the force reversed midway. They then produced similar force patterns in untrained 16 cm (or 8 cm) reaches. This generalization cannot be explained by movement states alone, suggesting the involvement of an abstract feature such as phase, which, in a single reach, is difficult to separate from acceleration. In Experiment 2, we dissociated phase from acceleration using a double-reach task. Opposing force fields were applied to either the first or second half of the overall movement. If the same motor primitives had been engaged in both halves, interference would be expected. However, participants successfully learned both fields, suggesting a separation of motor primitives between the first and second halves of the movement. In Experiment 3, we used a button–reach–button task to dissociate the reach phase within the overall movement sequence from the ordinal position of the reach itself. Participants learned opposing force fields depending on phase (at one-quarter vs. three-quarters in the overall movement). Since the reach was always the second action, the observed separation of motor primitives must be attributed to its phase within the overall sequence. These results suggest that internal models are organized according to phase within a unified motor sequence.

Keywords: Motor learning, Phase , Motor primitives

Mapping Time and Space in Social Interactions with the Mirror and Rock-Paper-Scissor Games

*Julia Ayache[1,2], Marta Bieńkiewicz[2], Simon Pla[2], Pierre Jean[2], Alexander Sumich[1,3], Nadja Heym[1], Benoit G. Bardy[2]

1. NTU Psychology, Nottingham Trent University, Nottingham, 2. EuroMov Digital Health in Motion, Univ. Montpellier IMT Mines Alès, Montpellier, 3. Department of Psychology, Auckland University of Technology, Auckland

Introduction. During social interactions, individuals tend to fall into synchrony (i.e., temporal matching) and imitate each other (i.e., spatial matching). While synchrony and imitation have attracted considerable attention due to their association with affiliative tendencies, they are seldom investigated simultaneously. Furthermore, although often regarded as markers of "successful" interactions, being temporally and spatially matched is not always optimal for "efficient" interactions. Consequently, this study investigated the association between synchrony and imitation using two social interaction games known to elicit these behaviors: the Mirror and Rock-Paper-Scissors (RPS) games.

Methods. Twenty-six dyads completed the Mirror and the RPS games under three visual coupling conditions: (i) OPEN, where both participants could see each other; (ii) MIXED, where only one participant could see the other; and (iii) CLOSED, where neither could see the other. The OPEN and CLOSED conditions were counterbalanced across dyads to control for order effects. Movements were recorded using infrared cameras, and participants completed self-report measures of affective state and self-other overlap before and after each interaction

Results. Visual coupling influenced emotional arousal, perceived self-other overlap, and behavioral matching. When participants could see each other, they reported feeling more connected and aroused, and demonstrated increased spatiotemporal alignment in both the Mirror and RPS games. Notably, behavioral synchrony during the Mirror Game predicted imitation tendencies in the subsequent RPS game.

Conclusion. These findings suggest a robust link between temporal and spatial alignment, even in competitive contexts. Participants who exhibited stronger behavioral synchrony in the Mirror Game were more likely to adopt similar RPS strategies, indicating that coordinated movement may foster shared cognitive patterns. Ongoing analyses of EEG synchrony and inter-individual differences may further elucidate the neural and dispositional underpinnings of this association between acting and thinking together.

Keywords: Behavioral Matching, Synchrony, Imitation, Mirror Game, Rock-Paper Scissor Game

Sharing Timing in Physical and Virtual Spaces

*Julien Laroche[1], Julia Ayache[1], Marco Coraggio[2], Angelo di Porzio[2], Francesco de Lellis[3], Anna Katharina Hebborn[4], Andreas Panayiotou[5], Lyam Pepin[6], Panayiotis Charalambous[5], Simon Pla[1], Pierre Jean[1], Mario di Bernardo[2,3], Didier Stricker[4], Benoît Bardy[1]

1. EuroMov DHM, Univ. Montpellier, IMT Alès, 2. Scuola Superiore Meridionale, 3. Univ. Napoli "Federico II", 4. German Research Center for Artificial Intelligence, 5. CYENS, 6. Univ. Paul Valery Montpellier,

Communicating and connecting with others relies on fine-tuned embodied coordination. Yet, as our social lives increasingly shift online where movement cues become impoverished, our ability to connect meaningfully is getting challenged. While Virtual Reality (VR) offers promising opportunities for embodied interaction in digital spaces, little is known about how to best capture, render and foster embodied coordination in this medium. Hence the ShareSpace project aims to better understand the constraints of virtual spaces on multi-agent embodied coordination, with the goal to optimize both motion capture and rendering.We report a series of studies on group movement coordination performed in both physical and virtual reality. In the first two studies, triads and quartets synchronized arm movements and reported their experiences of social connection. Results show that the kinematic and social benefits of group synchrony observed in physical reality transfer to VR. However, while people accelerated their pace when synchronizing in physical settings, this tendency was reversed in VR, showing how digital constraints can alter coordination strategies. In a subsequent VR study, we restricted participants' field of view to examine their interaction strategies, and in some cases, replaced one human partner with an adaptive artificial agent. This agent shared a similar appearance but was driven by a cognitive architecture optimized for group coordination. The presence of the adaptive agent led to an increase in movement pacing, suggesting that it could counteract the decelerating effects of digital interaction on collective kinematics. Most participants did not detect the agent swap yet reported feeling less socially connected to partners who had been replaced. These findings show the critical role of subtle kinematic cues in social coordination and offer new guidelines to design hybrid digital spaces that support authentic group interaction.

Keywords: Group synchronization, Virtual Reality, Social connection, Artificial Agent

Juggling on the Moon: Adaptation of complex motor skills to simulated low-gravity enabled changes in tempo

*John Rehner Iversen[1], Akilesh Sathyakumar[1], Hyeonseok Kim[2], Makoto Miyakoshi[2], Wanhee Cho [3], Hirokazu Tanaka[4], Takahiro Kagawa[5], Makoto Sato[3], Scott Makeig[7], Hiroyuki Kambara[6], Natsue Yoshimura[3]

1. McMaster University, 2. Cincinnati Children's Hospital Medical Center, 3. Institute of Science Tokyo, 4. Tokyo City University, 5. Aichi Institute of Technology, 6. Tokyo Polytechnic University, 7. University of California San Diego

Many commonly used rhythmic timing tasks can be easily varied in tempo, revealing important scaling laws of timing behavior and aiding learning. In contrast, it is more challenging to vary the tempo of real-world physical tasks like three-ball juggling. To address this, our collaborators have developed a realistic VR visuo-haptic simulation of juggling under reduced gravity using a novel force-generating input device to realistically simulate the physics and proprioception of ball throwing and catching (Kambara et al, *Proc IDW*, 2022). The setup enables the experimental modification of juggling tempo in a way that is not possible in physical settings. Our prior work has shown that juggling training in reduced gravity can enhance skill acquisition in novices, potentially by facilitating the learning of bimanual motor sequencing. (Cho et al., *IEEE VRW*, 2025). Here we shift focus to expert jugglers adapting to slow tempo juggling to test hypotheses about temporal scaling in motor control: proportional scaling vs. constant hold time (which relate to the continuous vs. discrete timing duality in the rhythmic timing literature). We measured motor kinematics (hand trajectories and timing of ball catches and throws) in relation to ball trajectory to describe how these scale with juggling tempo manipulated by changing simulated gravity. Our initial results (though n=2) are that a third alternative is suggested: jugglers attempt to increase tempo in low gravity by using shorter throws. This behavior may reflect VR-specific constraints, such as narrower field of view and less realistic proprioceptive feedback, prompting design improvements including pacing stimuli and visual apex targets to encourage slower juggling. This behavioral foundation supports planned neural studies of temporal scaling of neural dynamics using new methods for movement artifact rejection (Kim et al., *Sensors*, 2023; *J Neur Meth*, 2025).

Keywords: motor learning, adaptation, timing, rhythm, tempo, juggling

Culture-Driven Plasticity and Imprints of Body-Movement Pace on Musical Rhythm Processing

*Ségolène M. R. Guérin[1,2], Emmanuel Coulon[2], Tomas Lenc[2,3], Rainer Polak[4], Peter Keller[5], Laurie Gallant[2], Antoine Boveroux[2], Sylvie Nozaradan[2]

1. URePSSS, Université du Littoral Côte d'Opale, 2. Institute of Neuroscience (IoNS), Université Catholique de Louvain (UCLouvain), 3. Basque Center on Cognition, Brain, and Language (BCBL), 4. RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion, University of Oslo, 5. Center for Music in the Brain, Department of Clinical Medicine, Aarhus University & The Royal Academy of Music Aarhus/Aalborg

Music naturally induces human movement through its rhythmic structure. Conversely, synchronised body movement can shape rhythm perception –a short-term effect that is likely influenced itself by lifelong cultural exposure. Yet, direct experimental evidence for both short- and long-term modulation of rhythm processing through movement remains limited.

To address this, we present a registered report using electroencephalography (EEG) and hand-clapping responses to a highly syncopated, metrically ambiguous rhythm derived from West/Central African musical traditions (N = 80). These neural and behavioural responses were recorded separately in participants from West/Central Africa and Western Europe before and after a body-movement session involving stepping and clapping to a cued beat (either three- or four-beats meter, the latter concurring with original music-cultural conventions).

African participants exhibited a significant short-term effect, clapping more consistently and in closer alignment with the beat as cued in the body-movement session. They also more reliably interpreted the rhythm in line with cultural conventions, both before and after movement. In contrast, European participants showed no significant short-term movement effect. A sibling study was then conducted on an additional Western cohort (N = 40), where the body movement session was replaced by watching audiovisual clips of individuals performing the same body movement as in the first study, while remaining still. In contrast with Study 1, behavioural responses to the cued beat were found to be significantly more consistent after the training session, suggesting that multisensory inputs, possibly activating motor representation without actual movement production, can elicit a short-term effect even when production of actual movement does not.

Finally, inconsistencies between neural and behavioural data in both studies suggest that a brief training session alone may not robustly stabilise a beat interpretation that can be automatically reactivated in neural activity after the movement cessation, particularly in response to a complex, syncopated rhythm. Nonetheless, when participants are compelled to move to such a rhythm, they can draw on learnt beat–rhythm association to guide movement timing.

Keywords: cross-cultural, EEG, frequency tagging, rhythmic entrainment, body movements

Evidence for neural categorization of rhythm in human newborns

*Francesca M. Barbero[1], Tomas Lenc[1,2], Alban Gallard[3], Nori Jacoby[4,5], Rainer Polak[6,7], Arthur Foulon[3], Sahar Moghimi[3], Sylvie Nozaradan[1,8]

1. Institute of Neuroscience (IoNS), University of Louvain (UCLouvain), 1348 Louvain-la-Neuve, 2. Basque Center on Cognition, Brain and Language (BCBL), Donostia-San Sebastian, 3. Groupe de Recherches sur l' Analyse Multimodale de la Fonction Cérébrale (GRAMFC, Inserm UMR1105), Université de Picardie, 80054 Amiens, 4. Computational Auditory Perception Group, Max Planck Institute for Empirical Aesthetics, Grüneburgweg 14, 60322 Frankfurt am Main, 5. Department of Psychology, Cornell University, Ithaca, NY 14853, 6. RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion, University of Oslo, 7. Department of Musicology, University of Oslo, 8. International Laboratory for Brain, Music and Sound Research (BRAMS), Montreal

Humans show an outstanding capacity to perceive, learn, and produce musical rhythms. These skills rely on mapping the infinite space of possible rhythmic sensory inputs onto a finite set of internal rhythm categories. What are the brain processes underlying rhythm categorization? One view is that rhythm categories stem from neurobiological predispositions constraining internal representations of rhythmic inputs. However, a growing body of work suggests that rhythm categorization is plastic, open to be shaped by experience over the course of life. To tease apart the relative contributions of neurobiological predispositions and experience in rhythm categorization, we measured neural responses to rhythm in healthy full-term human neonates, capitalizing on their minimal post-natal experience.
Scalp electroencephalography (EEG) was recorded from newborns while they were exposed to acoustic sequences consisting of repeating patterns of two inter-onset intervals ranging from isochrony (1:1 interval ratio) to long-short patterns (2:1 ratio). In a second experiment, we separately recorded neural (EEG) and behavioral (sensorimotor synchronization) responses to the same rhythms in adult participants. The data were analyzed using a novel approach combining frequency-domain and representational similarity analyses.
Preliminary results indicate significant rhythm categorization in neonates, with categories encompassing the 1:1 and 2:1 integer ratio rhythms, and with a categorical structure similar to the neural and behavioral responses of adults. These findings suggest that internal representations of rhythm may be biased towards categorical structure by neurobiological properties already in place at birth. This study thus paves the way to further investigate the neural processes by which these internal categories would be further shaped by individual and cultural experience, leading to the diversity in music perception and behaviors observed worldwide.

Keywords: musical behavior, development, rhythm perception, electroencephalography

Oral | Timing & Time Perception

Sun. Oct 19, 2025 10:45 AM - 12:15 PM JST | Sun. Oct 19, 2025 1:45 AM - 3:15 AM UTC Room 2(West B1)

[O9] Oral 9: Timing & Time Perception

Chair:Sae Kaneko(Hokkaido University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[O9-01]

How each heartbeat shapes neural processing of duration?

*Irena Arslanova[1], Magda Jaglinska[2], Manos Tsakiris[1] (1. Royal Holloway University of London (UK), 2. University College London (UK))

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[O9-02]

Mechanisms of Time Perception: Roles of Time-Frequency Power and Cross-Frequency Coupling

*Tereza Nekovarova[1,2], Veronika Rudolfova[1,2], Kristyna Maleninska[1], Ondrej Skrla[1], Jakub Svoboda[1], Jana Koprivova[1,3], Martin Brunovsky[1,3], Vlastimil Koudelka[1] (1. National Institute of Mental Health (Czech Republic), 2. Faculty of Natural Science, Charles University (Czech Republic), 3. 3rd Faculty of Medicine (Czech Republic))

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[O9-03]

Intra- and inter-individual variability in body-brain-behavioral rhythms: a multimodal study with smart wearables

*Antonio Criscuolo[1], Michael Schwartze[1], Sonja Kotz[1,2] (1. Maastricht University (Netherlands), 2. Max Planck Institute for Human Cognitive and Brain Sciences (Germany))

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[O9-04]

Ontogeny of rhythmic performances and contribution of motor and perceptual rhythmic preferences

*Pier-Alexandre Rioux[1], Nicola Thibault[1,2], Daniel Fortin-Guichard[3], Émilie Cloutier-Debaque[4], Simon Grondin[1] (1. Laval University (Canada), 2. CERVO, Brain Research Center (Canada), 3. McGill University (Canada), 4. University of Montreal Hospital Center (Canada))

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[O9-05]

Representational dynamics of subjective duration in the human brain

*Camille L. Grasso[1], Ladislas Nalborczyk[2], Virginie van Wassenhove[1] (1. CEA/DRF/Inst. Joliot, NeuroSpin; INSERM, Cognitive Neuroimaging Unit; Université Paris-Saclay, Gif/Yvette, 91191 France (France), 2. Aix Marseille University, CNRS, LPL (France))

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[O9-06]

Mouse Strain Differences in Time Estimation are Related to Impulsive Behavior

*MARIELENA EUDAVE-PATIÑO[1], JONATHAN BURITICÁ[2], JAIME EMMANUEL ALCALÁ TEMORES [2] (1. UNIVERSIDAD AUTÓNOMA DE AGUASCALIENTES (Mexico), 2. UNIVERSIDAD DE GUADALAJARA (Mexico))

How each heartbeat shapes neural processing of duration?

*Irena Arslanova[1], Magda Jaglinska[2], Manos Tsakiris[1]

1. Royal Holloway University of London, 2. University College London

We previously showed that perceived stimulus duration was distorted by autonomic signals arising from the heart, and that this temporal distortion was modulated by experienced arousal (Arslanova et al., 2023; Current Biology). Here, we present two studies that reveal the neural mechanisms underlying these effects using electroencephalography (EEG), testing if and how the subjective experience of duration arises from an intricate brain-heart interplay.

The first EEG study examined the neural correlates of temporal distortions when cardiac signals impacted emotionally neutral stimuli (i.e., participants judged the duration of visual Gabor patches), whereas the second EEG study focused on cardiac effects on duration perception under different levels of experienced arousal (i.e., participants judge the duration of faces showing neutral of fearful expression). The first EEG study (N = 40) showed that cardiac signalling supressed later stages of visual processing, which was correlated with contraction of perceived durations. The second EEG study (N = 41) revealed distinct mechanisms by which arousal and cardiac signals shape subjective duration perception –an early modulation by arousal, followed by a later modulation by cardiac signal.

Overall, these results reveal how cardiac signals shape subjective time experience by exerting top-down attenuation of sensory processing, how temporal information may be intrinsic to sensory response, and how affective context drives the effect of the heart on our sense of duration.

Keywords: duration perception, heart, cardiac phase, interoception, EEG

Mechanisms of Time Perception: Roles of Time-Frequency Power and Cross-Frequency Coupling

*Tereza Nekovarova[1,2], Veronika Rudolfova[1,2], Kristyna Maleninska[1], Ondrej Skrla[1], Jakub Svoboda[1], Jana Koprivova[1,3], Martin Brunovsky[1,3], Vlastimil Koudelka[1]

1. National Institute of Mental Health, 2. Faculty of Natural Science, Charles University, 3. 3rd Faculty of Medicine

Time perception in milliseconds to seconds range depends on complex neural dynamics, but its electrophysiological correlates remain poorly understood. This study examines how EEG mechanisms (cross-frequency coupling and EEG band power) relate to the precision and accuracy of temporal estimation.To investigate time perception, we used a pair-comparison task, where two sequential visual stimuli representing time intervals (3.2–6.4 s each, with a total duration of 9.6 s) were presented, and participants indicated which of these two intervals was longer. EEG data were recorded from 36 electrodes (10/20 system) at 1000 Hz, and preprocessed with bandpass filtering between 0.15–70 Hz.Linear regression models with regularization were applied to predict key metrics of temporal accuracy/precision: Point of Subjective Equality (PSE) and Just Noticeable Difference (JND), using PACz (phase-amplitude coupling) and frequency powers as predictors. The model was trained on data from the first session and tested on data from the second session to validate accuracy/precision predictions.A characteristic pattern of alpha and beta band activity –including reduced beta power –was observed in both power and coupling during the early part of the interval, and was associated with improved temporal discrimination. These findings highlight the role of oscillatory dynamics and frequency coupling in time perception.
Acknowledgment:This work was supported by the Johannes Amos Comenius Programme (OP JAK), project reg. no. CZ.02.01.01/00/23_025/0008715 and by the grant from the Ministry of Health Czech Republic (no. NU 22-04-00526).

Keywords: interval timing, pair-comparison task, EEG, phase-amplitude coupling

Intra- and inter-individual variability in body-brain-behavioral rhythms: a multimodal study with smart wearables

*Antonio Criscuolo[1], Michael Schwartze[1], Sonja Kotz[1,2]

1. Maastricht University, 2. Max Planck Institute for Human Cognitive and Brain Sciences

Our sensory environment features a multitude of temporal regularities: there are temporally regular patterns in speech and music, as well as in bodily physiological activity.Is there a precise relationship between individual bodily (e.g., cardiac) and behavioral (e.g., walking) rhythms? Some authors suggested the existence of a cross-frequency architecture characterized by harmonic relations [1]: if your heart beats at 1.25Hz, your breathing rate may be a subharmonic (˜.25Hz), while the speaking rate an harmonic (syllable rate: ˜2.5Hz). The same may hold for perception and synchronization: sensory processing may prefer input at harmonic relations with your heartbeat, and you may synchronize more easily to music in close proximity to your preferred tempo.In an ongoing study, we are using a combination of smart wearable technology (fitness tracker, mobile EEG, smart glasses), to assess individual breathing, cardiac and brain signals, along with eye movements, pupil dilation and motion tracking. Participants engage in a series of tasks ranging from resting state and listening tasks, to spontaneous tapping, speaking and walking. Within a dynamic system framework [2], our goals are to: (i) characterize intra- and inter-individual variability in body-brain-behavioral rhythms; (ii) test the hypothesis of individual cross-frequency architectures in body-behavioral rhythms; (iii) describing if and how dynamic body-brain interactions shape perception and action.Findings promise to advance our understanding of how complex body-brain interactions shape information processing, behavior and adaptation. Promoting individualized and integrative research approaches, our results may further support translational research in clinical populations characterized by altered rhythms (e.g., Parkinson’s).

References

Klimesch, W. The frequency architecture of brain and brain body oscillations: an analysis. *European Journal of Neuroscience* 48, 2431–2453 (2018).
Criscuolo, A., Schwartze, M. & Kotz, S. A. Cognition through the lens of a body–brain dynamic system. *Trends Neurosci* (2022) doi:10.1016/J.TINS.2022.06.004.

Keywords: rhythm, body-brain interactions, smart wearable, perception, action

Ontogeny of rhythmic performances and contribution of motor and perceptual rhythmic preferences

*Pier-Alexandre Rioux[1], Nicola Thibault[1,2], Daniel Fortin-Guichard[3], Émilie Cloutier-Debaque[4], Simon Grondin[1]

1. Laval University, 2. CERVO, Brain Research Center, 3. McGill University, 4. University of Montreal Hospital Center

According to the entrainment region hypothesis, the range of tempi with which individuals can synchronize broadens during childhood. This developmental change is accompanied by a slowing of rhythmic preferences, as covered by the preferred period hypothesis. The later hypothesis posits that both motor and perceptual rhythmic preferences slow down throughout childhood, reflecting an increase in the common period of endogenous oscillations. This study aimed to provide a developmental profile of rhythmic performances (counting and tempo discrimination), while investigating the related contributions of a preferred period (spontaneous motor tempo and perceptual preferred tempo). The study (N = 70) included three groups of children (5-6, 8-9, and 11-12 years) and one group of young adults (21-30 years), all tested at the same time of day. The results show a change in rhythmic performances between the ages of 8-9 and 11-12, as well as a variable contribution of rhythmic preferences, depending on the task employed. Moreover, results indicate a significant effect of rhythmic context in tempo discrimination, suggesting that young children can discriminate tempi slower than their rhythmic preferences. This study nuances the bias of rhythmic performance towards rhythmic preferences, notably because the tasks employed to measure rhythmic performance indicate different developmental trajectories, in addition to varying in their relationships to rhythmic preferences. It is suggested that the cognitive demands relative to the task employed to measure rhythmic performances could underlie developmental differences and mask biases towards rhythmic preferences, particularly in younger children.

Keywords: Rhythm, Preferred Tempo, Entrainment, Development

Representational dynamics of subjective duration in the human brain

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How is time represented in the mind and brain? While durations are often thought to be mapped along a mental timeline (*i.e., a unidimensional spatialized representation of durations*), such a view may oversimplify the complexity of temporal representations. In this talk, I will present a project that investigates the geometry of duration representations by combining behavioral similarity judgments and representational similarity analysis of EEG data. We asked participants to rate the similarity of pairs of auditory durations and, in a separate session, recorded EEG while they performed an oddball detection task with the same stimuli. These data were used to construct representational dissimilarity matrices, which we projected into lower-dimensional spaces to visualize and compare the conceptual and neural structure of duration representations. Crucially, we explored whether the structure of neural responses could predict participants’ behavioral similarity judgments, and whether these shared structures reflected non-linear or multi-dimensional embeddings—such as helical structures—rather than simple linear mappings. We further examined how classic EEG markers of timing, such as the contingent negative variation, relate to these geometrical structures. This work contributes to a growing line of research aiming to uncover the geometry of mental representations and offers a new perspective on how durations may be encoded in the brain.

Keywords: temporal cognition, subjective duration, neural dynamics , representational dynamics

Mouse Strain Differences in Time Estimation are Related to Impulsive Behavior

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Differences between mouse strains have significantly impacted the results of various studies; however, the underlying sources of these differences remain unclear. Differences among mouse strains have been observed in locomotor activity, lever and nosepoke responses, impulsivity, and temporal estimation. Some studies suggest that these differences may be linked to genetics of the strains, although further research is needed to clarify these findings. The objective of this experiment was to test CD1 and C57BL/6 strains using a peak procedure, a progressive ratio schedule, a modified peak procedure, and a differential reinforcement of low rate (DRL) schedule. These procedures were used to determine whether there were differences in time estimation and the factors influencing performance on such schedules. The analysis of the curvature index in fixed interval (FI), peak, and modified peak procedures revealed that CD1 mice exhibited a higher curvature index compared to C57BL/6 mice. Additionally, differences in performance were observed in the analysis of peak trials within the peak and modified peak procedures, with CD1 mice showing a higher response rate at the start of the trial compared to C57BL/6 mice. In the progressive ratio, the post-reinforcement pause was longer in the C57BL/6 strain than in CD1 mice, but no significant differences were found in breakpoint levels between the two strains. In DRL procedure, C57BL/6 mice displayed higher inter-response times (IRTs) compared to CD1 mice, and the distribution of IRTs differed according to strain. These results indicate that there are strain-related differences in postprandial behavior that may be associated with impulsivity. Specifically, CD1 mice appear to exhibit greater impulsivity compared to C57BL/6 mice, as evidenced by their behavioral patterns in the tasks analyzed

Keywords: temporal estimation, strain differences, impulsive behavior, mice

Oral | EEG, MRI, TMS

Sun. Oct 19, 2025 1:00 PM - 2:30 PM JST | Sun. Oct 19, 2025 4:00 AM - 5:30 AM UTC Room 3(East B1)

[O10] Oral 10: EEG, MRI, TMS

Chair:Masamichi J Hayashi(Center for Information and Neural Networks (CiNet))

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

[O10-01]

Common EEG connectivity patterns between time reproduction and working memory

*Sergio Rivera-Tello[1], Julieta Ramos-Loyo[1] (1. University of Guadalajara (Mexico))

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

[O10-02]

Perception of short, but not long, time intervals is modality-specific: Converging electroencephalography evidence from vibrotactile and auditory modalities

*Nicola Thibault[1,2], Pier-Alexandre Rioux[1], Andréanne Sharp[1,2], Philippe Albouy[1,2,3], Simon Grondin[1] (1. Université Laval (Canada), 2. CERVO Brain Research Centre (Canada), 3. International Laboratory for Brain (Canada))

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

[O10-03]

Orthogonal Codes for Time and Decision in Human Temporal Perception

*Andre Mascioli Cravo[1], Mateus Silvestrin[3], Peter Maurice Erna Claessens[1], Nicholas Myers[2] (1. Universidade Federal do ABC (UFABC) (Brazil), 2. School of Psychology, University of Nottingham, UK (UK), 3. Federal University of the São Francisco Valley (Brazil))

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

[O10-04]

Shared spectral fingerprints of temporal memory precision and representation of the temporal structure of complex narratives

*Matteo Frisoni[1], Pierpaolo Croce[2], Annalisa Tosoni[2], Filippo Zappasodi[2], Carlo Sestieri[2] (1. University of Bologna (Italy), 2. University D'Annunzio Chieti Pescara (Italy))

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

[O10-05]

Defining a functional hierarchy of millisecond time: from visual stimulus processing to duration perception

*Valeria Centanino[1], Gianfranco Fortunato[1], Domenica Bueti[1] (1. International School for Advanced Studies (SISSA) (Italy))

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

[O10-06]

The chronometry of time processing in visual and premotor areas

*Domenica Bueti[1] (1. International School for Advanced Studies (SISSA) (Italy))

Common EEG connectivity patterns between time reproduction and working memory

*Sergio Rivera-Tello[1], Julieta Ramos-Loyo[1]

1. University of Guadalajara

Time perception is a fundamental cognitive ability crucial for survival, relying on the integration of multiple processes, including working memory (WM)—the brain's capacity to temporarily encode, maintain, and manipulate information. Both functions depend on the synchronization and coupling of brain rhythms. Previous literature has suggested a strong relationship between both processes, where higher WM-capacity correlates with higher timing accuracy. Here we examined EEG correlation patterns during intervallic time reproduction, 2.5 s, and a letter n-back task (2-level). Fifty-two participants (28 women) performed both tasks. EEG correlation matrices were computed for each frequency band (theta, alpha1, alpha2 and beta1), then we compute a similarity test to compare connectivity patterns between 2-back and time reproduction. Results indicate similar connectivity patterns mainly in theta (*rho=77*) and alpha2 (*rho=63*) bands. We also found a behavioral relationship between WM-capacity and temporal precision (*r=0.49*). These findings contribute to understanding the shared oscillating mechanisms between time perception and working memory, offering insights into brain connectivity dynamics.

Keywords: EEG, Connectivity, Working Memory, Time Reproduction

Perception of short, but not long, time intervals is modality-specific: Converging electroencephalography evidence from vibrotactile and auditory modalities

*Nicola Thibault[1,2], Pier-Alexandre Rioux[1], Andréanne Sharp[1,2], Philippe Albouy[1,2,3], Simon Grondin[1]

1. Université Laval, 2. CERVO Brain Research Centre, 3. International Laboratory for Brain

A longstanding debate in cognitive neuroscience questions whether temporal processing is modality-specific or governed by a “central clock” mechanism. We propose that this debate stems from neglecting the duration of the intervals processed, as studies supporting modality-specific models of time perception often focus on below 1.2-s intervals. To address this, we studied the neuronal dynamics underlying the vibro-tactile perception of time intervals shorter and longer than 1.2-s. Twenty participants underwent electroencephalography recordings during a passive vibrotactile oddball paradigm. We compared brain responses to standard and deviant intervals, with deviants occurring either earlier or later than the standard in both below and above 1.2-s conditions. Event-related potentials revealed distinct deviance-related components: a P250 for deviance detection of below 1.2s and an N400 deviants for above 1.2s. Generators lied in a modality-specific network for below 1.2s intervals, while above 1.2s intervals activated a broader, higher-level network. We found no evidence of the contingent negative variation in the tactile modality, questioning its role as a universal marker of temporal accumulation. Our findings suggest that short intervals involve modality-specific circuits, while longer intervals engage distributed networks, shedding light on whether temporal processing is centralized or distributed. These findings are also in line with our previous results (Thibault al., 2023, 2024) using the auditory modality, where short auditory intervals recruited sensory regions while longer intervals elicited a more distributed network.

Keywords: EEG, Intervals, Oddball, Time perception, Vibrotactile

Orthogonal Codes for Time and Decision in Human Temporal Perception

*Andre Mascioli Cravo[1], Mateus Silvestrin[3], Peter Maurice Erna Claessens[1], Nicholas Myers[2]

1. Universidade Federal do ABC (UFABC), 2. School of Psychology, University of Nottingham, UK, 3. Federal University of the São Francisco Valley

Time perception involves estimating physical durations and making categorical judgments relative to reference intervals. However, most studies conflate these processes, limiting insight into how they are encoded in brain activity. Here, we used EEG and multivariate pattern analysis (MVPA) to dissociate neural representations of time and decision during a temporal discrimination task. Thirty participants compared variable intervals to block-specific references, with duration and categorical status (shorter, equal, or longer) manipulated orthogonally. Behaviorally, responses were shaped by target duration, categorical judgment, and recent trial history. An Internal Reference Model (IRM) indicated that participants dynamically updated their internal reference over trials. MVPA showed that both physical duration and categorical decision information were encoded throughout the trial, though with distinct temporal profiles. These signals were represented along orthogonal neural dimensions, enabling their separation in brain activity. These findings suggest that time perception relies on parallel, functionally distinct processes for tracking duration and making temporal decisions, supporting models that treat them as independent components of temporal evaluation.

Keywords: Temporal decision, EEG, MVPA

Shared spectral fingerprints of temporal memory precision and representation of the temporal structure of complex narratives

*Matteo Frisoni[1], Pierpaolo Croce[2], Annalisa Tosoni[2], Filippo Zappasodi[2], Carlo Sestieri[2]

1. University of Bologna, 2. University D'Annunzio Chieti Pescara

The ability to organize events in time is a hallmark of episodic memory. fMRI studies have implicated the entorhinal-hippocampal system in temporal precision and event structure representation. However, little is known about the temporal dynamics and broader neural substrates of these processes. This EEG study explored (a) whether temporal precision and structural representation are related, (b) when they occur, and (c) whether they involve areas beyond the medial temporal lobe. Twenty participants viewed a movie and later placed short video clips on a horizontal timeline, estimating their time of occurrence. This task provided behavioral indices of temporal precision and subjective distances between clips. We applied multivariate pattern analysis (MVPA) on time-frequency EEG data to decode temporal precision, and representational similarity analysis (RSA) to compare neural and behavioral distances. MVPA revealed a signature of temporal precision in the high beta/low gamma range (28–40 Hz) during timeline presentation. Crucially, RSA showed that the same time-frequency window reflected the structure of temporal representations: brain activity patterns across all electrodes scaled with participants' perceived temporal distances. The two measures—precision and structure—were also correlated: greater accuracy aligned with more structured representations. We found that oscillatory activity in the high beta/low gamma frequency codes for temporal memory precision. And the same widespread distribution of activity also codes for the mnemonic representation of the temporal structure of the event. These results bridge the gap between separate recent findings in the literature on temporal memory for complex events, and shed new light on how complex events of our life become "infused with time".

Keywords: temporal memory, episodic memory, EEG, temporal event representation, movies

Defining a functional hierarchy of millisecond time: from visual stimulus processing to duration perception

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1. International School for Advanced Studies (SISSA)

In humans, the neural processing of millisecond time recruits a wide network of brain areas and involves different types of neural responses. Unimodal tuning to stimulus duration, for example, has been observed in some of these regions, though its presence is either inconsistently reported or appears redundant along the cortical hierarchy. Moreover, how duration tuning supports perception or contributes to different functional outcomes remains largely unexplored. To address these gaps, we measured brain activity using ultra-high-field (7T) functional MRI while participants performed a visual duration discrimination task. Using neuronal-based modeling, we estimated unimodal responses to durations across numerous cortical areas, defined with high anatomical precision. In the parietal and premotor cortices, as well as the caudal supplementary motor area (SMA), we observed neuronal populations tuned to the entire range of presented durations, with a clear topographic organization. In contrast, in the rostral SMA, inferior frontal cortex, and anterior insula, neuronal units showed duration preferences centered around the mean of the presented range. These preferences also correlated with the perceptual boundary that participants used to perform the task. The observed differences in tuning preferences, their spatial clustering, and their behavioral correlations suggest specialized functional roles across cortical regions in temporal processing—from an abstract duration representation for readout and motor-related goals in the parietal and premotor cortices, to a categorical and subjective duration representation in the insula and inferior frontal cortex. In line with these hypothesized roles, we also observed distinct patterns of correlation in duration preferences across these areas. Collectively, our findings provide a comprehensive framework of duration processing and perception in vision, highlighting its distributed and hierarchical nature.

Keywords: duration tuning, duration perception, 7T-fMRI, temporal hierarchy

The chronometry of time processing in visual and premotor areas

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In humans, processing the duration of a visual event involves a network of brain areas, including the primary visual cortex (V1) and supplementary motor area (SMA). However, their functional roles in temporal computation remain unclear. A simple hypothesis is that V1, conveying sensory input, encodes duration, while SMA, at the top of a processing hierarchy, decodes it for task-related purposes. We tested this in two transcranial magnetic stimulation (TMS) studies, one of which combined twin-coil TMS with EEG, to investigate the direction and timing of V1–SMA communication. In both studies, TMS was applied while healthy volunteers (n = 15 per study) performed a visual duration discrimination task. In Study 1, paired-pulse TMS (ppTMS) was applied over right V1, SMA, or Vertex (control site) at four time points (0%, 60%, 90%, 100%) relative to the first stimulus onset. Compared to Vertex, ppTMS over V1 at 60% and SMA at 90% and 100% significantly impaired discrimination thresholds. We modeled the data using four variants of a leaky integrator model differing in the locus (input vs. perceptual) and nature (mean vs. variance) of TMS-induced noise. The best-fitting models suggested that TMS increased noise variance, with V1 and SMA effects best explained by interference at the input and perceptual levels, respectively.In Study 2, TMS was delivered within-trial over both regions in two orders (V1–SMA vs. SMA–V1) and at varying inter-pulse intervals (IPIs). Performance was most impaired when TMS was applied to SMA at stimulus offset, followed 0.1 s later by V1 stimulation. This impairment correlated with reduced EEG-based duration representation. Moreover, alpha power predicted decision criteria at long IPIs, with stronger alpha linked to a more conservative bias. These findings reveal distinct roles of V1 and SMA in duration processing and provide causal evidence for feedback communication and the role of alpha oscillations in temporal decision-making.

Keywords: Neural mechanisms, TMS EEG , Computational modelling