EEG and MEG methods multi-hub meeting GENOVA GARDEN-ITALY

16-19 October 2023

Department of Informatic, Bioengineering, Robotics and Systems Engineering – University of Genova
Via Dodecaneso, 35, 16146 Genova GE

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SIPF Società Italiana di Psicofisiologia e Neuroscienze Cognitive

BESA

WELCOME TO CUTTING GENOVA GARDEN - ITALY

About

CuttingGardens is a distributed conference on cuttin-edge methods for M/EEG data analysis. It happens simultaneously in several locations (aka. Gardens) across the world, with a common global program, broadcasted to all locations, and local programs made of talks, tutorials, posters, social events, satellites… as each Garden (optionally) sees fit. CuttingGardens is part of the CuttingEEG conference series.

In Italy, **Genova** has the honour to host one of the Gardens, offering several in-person talks and tutorials, with some sessions broadcasted across all Gardens.

Our aim is to give you:

- Basic knowledge of EEGLAB
- Performing Source Localization analysis with SESAME
- Use of EEG to study typical and atypical development
- Integrating the EEG with eye-tracking and TMS
- Good practice in M/EEG studies

Organizing Committee

- Alberto Sorrentino
University of Genova
- Alessandro Viani
University of Genova
- Annalisa Pascarella
University of Genova
- Andrea Vitale
University of Trento
- Camillo Porcaro
University of Padova
- Caterina Piazza
RCCS Medea
- Chiara Cantiani
IRCCS Medea
- Chiara Mazzi
University of Verona
- Carola Dolci
University of Verona
- Davide Bonfanti
University of Verona
- Elena Bertacco
University of Verona
- Elisabetta Colombari
University of Verona
- Ermanno Quadrelli
University of Milano-Bicocca
- Gianvittorio Luria
University of Genova
- Silvia Polver
University of Padova

SCIENTIFIC PROGRAM

MONDAY 16th – Day 1

09:45 – Opening remarks

10:00 – Local Talk 1
From dolphins to sleep walkers. Sleep as a global and local Phenomenon —Lino Nobili

11:00 – Coffee Break

11:30 – Local Talk 2
Source reconstruction in M/EEG—A. Sorrentino

12:00 – Tutorial 1
Hands-on SESAME : a multi-dipole localization method — A. Pascarella, A. Viani, G. Luria

13:00 – Lunch

14:30 – [Global] Theoretical advances in Cognitive Neuroscience made through MEEG

- *The Gut-brain-consciousness Axis—C. Tallon-Baudry*
- *Tracking Attentional Dynamics Across Vision, Working Memory, and Action —S. Kotz*
- *Emergence of language during early development —F. de Lange*

17:00 – Discussion

17:30 – Welcome

TUESDAY 17th – Day 2

09:00 – Tutorial 2
Preprocessing with EEGLAB – C. Porcaro, C. Piazza

11:00 – Coffee Break

11:30 – Tutorial 3
EEG and eye-tracking integration – C. Huber-Huber, A. Vitale

13:00 – Lunch

14:30 – [Global] Challenges/opportunites in RT EEG processing and classification tools in BCI

- *Geometric deep learning meets BCI – R. Kobler*
- *Facing the Small Data Reality – M. Tangermann*
- *Conducting BCI protocols with Patients – T. Vaughan*

17:00 – Discussion

17:30 – Posters & Beer

WEDNESDAY 18th – Day 3

09:00 – Local Talk 3

- *EEG to study typical and atypical development: Issues and Practices—C. Cantiani*
- *The developmental origins of embedded neural oscillations for speech and language processing: the role of prenatal and early postnatal experience – J. Gervain*
- *Frequency-tagging: a powerful method to investigate neurocognitive development with EEG – M. Buiatti*
- *A developmental approach to EEG cortical source analysis – S. Conte*

11:00 – Coffee Break

11:30 – Tutorial 4

Artfifact removal pipelines for human newborn EEG data –V. Prabhakar Kumaravel

13:00 – Lunch

14:30 – [Global] Reproducible processing pipelines and multiverses

- *EEGmanypipelines – E. Cesnaite*
- *The Data-Processing Multiverse of Event-Related Potentials – P. Clayson*
- *Agreed Reporting Template for EEG Methodology – International Standard – A. Šoškić*

17:00 – Discussion

17:30 – Posters & Beer

20:00 – Social event

THURSDAY 19th – Day 4

09:00 – Local Talk 4

- *Comparison of different TMS-EEG cleaning pipelines: Advantages, Issues and Challenges – P. Belardinelli and A. Brancaccio*
- *Effective and functional connectivity analysis of TMS-EEG data – A. Pisoni*

11:00 – Coffee Break

11:30 – Tutorial 5

Real-time monitoring of TMS-evoked potentials to improve data quality – S. Casarotto

13:00 – Lunch

14:30 – [Global] Deep neural network analysis of MEEG data: A roadmap to using machine learning with MEEG

- *Learning M/EEG Representations with Self-Supervision – H. Banville*
- *Classic Machiane Learning versus Deep Learning: Is there a clear winner – M. De Vos*
- *Using Artificial DNN to Predict and understand human vision – R. Martin Cichy*

17:00 – Discussion

17:30 – Final Greetings

POSTER PRESENTATION

TUESDAY 17th – Day 2

- *Infants' neural processing of emotional faces is affected by ostracism*
  G. Basset, E.Quadrelli, J. Mermier, H. Bulf, C. Turati
  University of Milano-Bicocca
- *Impact of Task-Irrelevant Emotional Stimuli on Visual Search*
  S. Biberci, C. Dolci, C. Della Libera, B. Monachesi, L. Chelazzi
  University of Verona
- *Synchronizing with the rhythm: infant neural entrainment to musical and speech stimuli*
  C. Dondena, M. Borromini, V. Riva, M. Molteni, C. Piazza, C. Cantiani
  IRCCS Eugenio Medea
- *Acting jointly is not just acting side-by-side: An EEG hyper-scanning study*
  M. Fanghella, G. Barchiesi, A. Zazio, A. Battaglia, Mayer, M. Bortoletto & C. Sinigaglia
  University of Milan
- *Temporal dynamics of size constancy for perception and action with real objects at real distances*
  S. Noviello , S.K. Songhorabadi, J. Chen , C. Zheng, A. Pisani , Z. Deng, E. Franchin, E. Pierotti, E. Tonolli, S. Monaco, L. Renoult & I. Sperandio
  University of Trento
- *Baseline EEG in the first year of life: insights into the development of autism spectrum disorder and language impairments*
  C. Piazza, C. Dondena, E. M.Riboldi, V. Riva, C. Cantiani
  IRCCS Eugenio Medea
- *Understanding human spatial navigation skills: an EEG study in immersive virtual reality*
  S. Rapella, S. Bellazecca, G. Andreoni, E. Biffi, C.Piazza
  Associazione La Nostra Famiglia
- *An integrated EEG and eye-tracking approach for the study of audiovisual sensory processing in infants at elevated likelihood of being autistic*
  E. Capelli, L. Billeci, G. Federico, E. M. Riboldi, C. Beretta, M. Molteni, V. Riva
  Associazione La Nostra Famiglia
- *The role of aperiodic component in discriminating altered EEG activity in a population of stroke patients*
  S. Zago, A. Gacnik, F. T. Hojs, M. Rakusa, G. Arcara
  IRCCS San Camillo

POSTER PRESENTATION

WEDNESDAY 18th – Day 3

- *Exploring the neurophysiological effects of a visuomotor paired associative stimulation protocol: a TMS-EEG study*
  ***E.* Arrigoni, G. Guidali, N. Bolognini, A. Pisoni**
  University of Milano-Bicocca
- *Visual Rule Learning advantage in preverbal infants over adults: evidence from neural entrainment*
  R. Bettoni, H. Bulf, V. Silvestri, S. Peykarjou & V. M. Cassia
  University of Milano-Bicocca
- *Central and peripheral correlates of negative expectations: toward a new model to explain functional neurological disorders*
  I. Lozzi, A. M. Emadi, A. Marotta, M. Tinazzi, M. Fiorio
  University of Verona
- *The role of current direction and pulse waveform on the modulation of an early TMS-evoked potential component*
  D. Lucarelli, G. Guidali, A. Zazio, E. Marcantoni, A. Stango, G. Barchiesi, M. Bortoletto
  IRCCS Istituto Centro San Giovanni di Dio Fatebenefratelli
- *Brain connectivity and electrocortical signals related to error processing: a combined TMS-EEG- immersive virtual reality study*
  S. Petkovic, F. Rossano, G. Fusco, S. M. Aglioti
  Sapienza University of Rome
- *Familiar rhythmic structures facilitate predictions about upcoming stimuli in the newborn brain*
  S. Polver, M. C. Ortiz-Barajas, J.Gervain
  University of Padova
- *Identification of very early components for TMS-evoked potentials*
  A. Stango, G. Guidali, A. Zazio, D. Lucarelli, E. Marcantoni, G. Barchiesi, M. Bortoletto
  IRCCS Istituto Centro San Giovanni di Dio Fatebenefratelli
- *The neural correlates of word order in pre-lexical infants: a frequency-tagging approach*
  M.Turconi, J. Gervain
  University of Padova

TALK ABSTRACTS

MONDAY 16th – Day 1

Source reconstruction in M/EEG

Alberto Sorrentino[1]
[1]*Department of Mathematics, University of Genova, Italy*

In several applications it is either necessary or at least useful to localize, in time and space, the neural generators of the measured M/EEG data. To this aim it is necessary to perform an analysis step often referred to as source reconstruction. In this talk, we will provide a brief overview of the field, focusing on the following aspects:
1. Source reconstruction is technically not possible, as the data do not contain enough information to fully recover their exact generators; we should rather call this step source guessing (or estimation, if we want to be statistically correct).
2. Due to point 1. above, it is preferable to have a probability distribution, rather than a single guess, as a solution of the problem; this is what Bayesian methods do.
3. When accurate localization is needed, an accurate forward model should be used in combination with a recent inverse method; recent inverse methods tend to outperform older ones, although they are not much used yet [Pascarella et al., NeuroImage 2023]

TALK ABSTRACTS

TUESDAY 17th – Day 2

Preprocessing with EEGLAB

Camillo Porcaro[1], Caterina Piazza[2]
[1] Department of Neuroscience and Padova Neuroscience Center (PNC), University of Padova,Italy
[2] Scientific Institute, I.R.C.C.S. "E.Medea", Bosisio Parini, Italy

EEGLAB (Delorme & Makeig, 2004) is a Matlab toolbox for analyzing continuous and event-related EEG, MEG and other electrophysiological data. Over the last 19 years, it has become one of the most used environment for human EEG data processing, with contributions from the scientific community in terms of programming, plug-ins preparation, and especially use.
The present tutorial will introduce and demonstrate the use of the EEGLAB software environment and EEGLAB-linked tools for performing the preprocessing of EEG data, with detailed method expositions and practical exercises.
The session will begin with a brief introduction about neural basis and measurement of EEG signal. This will be followed by a detailed description of a preprocessing pipeline in EEGLAB. Each preprocessing step will be practically executed using a real dataset. Alternative methods of analysis will be presented using various EEGLAB tools. The final part of the tutorial will be devoted to the Independent Component Analysis (ICA), introduced both theoretically and practically.
At the end of the session participants will have acquired the skills necessary to process their EEG data

EEG and eye-tracking integration

Christoph Huber-Huber[1], Andrea Vitale[2]
[1] Center for Mind/Brain Sciences (CIMeC), University of Trento, Italy
[2] Laboratory for Autism and Neurodevelopmental Disorders, CNCS @UniTn, Istituto Italiano di Tecnologia, Rovereto, Italy

In this hands-on session, we will process an EEG dataset with concurrently recorded eye-tracking data using the EEGLAB and EYE-EEG toolboxes in Matlab. The dataset was originally recorded to investigate the impact of active gaze behavior on early stages of visual processing. We start with a brief introduction to eye-tracking and eye-movement artifacts in the EEG. We will, then, analyze the data from a set of participants. We will give advice on synchronization, eye-tracker-supported ICA, and deconvolution methods (unfold toolbox). In sum, our hands-on session will demonstrate how to work with coregistered EEG and eye-tracking data and it will highlight the importance of considering eye movements when working with EEG in general. There will be time for dealing with general questions and specific issues by the attendees. Eventually, we will provide suggestions and feedback to EEG and eye-tracking studies that have already been conducted or are being planned.

TALK ABSTRACTS

WEDNESDAY 18th – Day 3

EEG to study typical and atypical development: Issues and Practices

Chiara Cantiani [1]
[1] *Child Psychopathology Unit, Scientific Institute, IRCCS Eugenio Medea, Lecco, Italy*

EEG is one of the primary experimental technique allowing researchers to advance the understanding of early typical and atypical brain development. Despite its importance in getting meaningful information and in driving theoretical advances, this methodology is rapidly evolving and present unique challenges when applied to the study of infant brains. In this introductory talk, I will present an overview of the main challenges regarding (1) paradigm selection, (2) EEG data acquisition, and (3) EEG/ERP data processing/analyses. Most of the open points will be addressed by the specific talks and in the hands-on included in the session. Hopefully, the session will result in a fruitful discussion with the experts in the field of developmental EEG in order to highlight good data collection and processing practices to maintain and increase the integrity of the field.

The developmental origins of embedded neural oscillations for speech and language processing: the role of prenatal and early postnatal experience

Judit Gervain [1]
[1] *Department of Developmental and Social Psychology, University of Padova,Italy*

Hearing is operational from the 24-28th week of gestation, so fetuses are immersed in a rich auditory environment and encounter, among other sounds, spoken language for the first time. However, the speech signal is low-pass filtered by maternal tissues and the intrauterine environment, suppressing individual sounds, but preserving prosody, i.e. the rhythm and melody of speech. Once they are born, infants get exposed to the full-band speech signal. The talk will report a series of EEG studies with newborns and young infants, investigating what fetuses and young infants learn from the prenatal, low-pass filtered and postnatal full band speech signal. A first study investigates whether newborns and 6-month-old infants track the envelope of speech, a signal that is sufficient for adults to understand speech in silence, and if yes, whether there are differences in speech envelope tracking ability at birth and later. A second study assesses whether the hierarchy of embedded neural oscillations known to underlie speech processing in adults (e.g. Giraud & Poeppel 2012) is already present at birth, and if yes, whether it is already shaped by prenatal experience. The results suggest that the oscillatory hierarchy is indeed operational from birth, is shaped by prenatal experience with speech and shows developmental changes between birth and 6 months. A third study establishes a neural signature of learning from the native speech input by assessing how neural activation, in particular its long-range temporal dynamics, change after exposure to speech in the native language. The talk will end by discussing the theoretical implications of these mechanisms for early speech perception and later language development.

TALK ABSTRACTS

WEDNESDAY 18th – Day 3

Frequency-tagging: a powerful method to investigate neurocognitive development with EEG

M. Buiatti [1]
[1] Center for Mind/Brain Sciences (CIMeC), University of Trento, Italy

Measuring stimulus-related neural activity with electroencephalography (EEG) in developmental populations is a challenging task: compared to adults, datasets are much shorter due to the infants' limited attentional span and much noisier due to uncontrollable movements. Frequency-tagging is an experimental design that minimizes these constraints by presenting the (potentially multiple) relevant features of the stimuli in a continuous oscillatory stream and by computing distinct feature-related responses at the frequency of feature occurrence, which yield a much higher signal-to-noise ratio than traditional event-related designs. The purpose of this talk is to provide indications on the optimal use of frequency-tagging in developmental EEG studies. Throughout the review of key studies on infants and newborns, I will stress that the methodological challenge of frequency-tagging in development lays in the simultaneous extreme of short data and low tag frequencies, the latter required both to investigate higher-level cognition and to match the maturation limits of the youngest subjects. I will discuss the efficiency of standard amplitude and phase measures, as well as a novel one, when tackling this limit.

A developmental approach to EEG cortical source analysis

S. Conte [1]
[1]Department of Psychology, State University of New York at Binghamton, United States

Cortical source reconstruction of electroencephalographic (EEG) signals can be an informative tool for the analysis of brain activity. The aim of source reconstruction is to identify the cortical generators (sources) of the EEG signal recorded on the scalp. The quality of the source reconstruction relies on the accuracy of the solutions to the forward problem, and consequently the inverse problem. An accurate forward solution is obtained when an appropriate imaging modality (i.e., structural magnetic resonance imaging, MRI) is used to describe the head geometry, precise electrode locations are identified with 3D maps of the sensor positions on the scalp, and realistic conductivity values are determined for each tissue type of the head model. Together these parameters contribute to the definition of realistic head models and can improve the accuracy with which the generators of the neural activity are localized. In the current presentation I will be describing the main steps of the pipeline for source localization of ERP responses, with reference to the adjustments necessary when applying this procedure to pediatric populations. Alternative approaches will be discussed with respect to the construction of the head model and electrode maps. I will conclude with an overview of the advantages and limitations of the procedure compared with alternative neuroimaging techniques.

TALK ABSTRACTS

WEDNESDAY 18th – Day 3

Artfifact removal pipelines for human newborn EEG data

Velu Prabhakar Kumaravel [1]
[1] University of Trento, Italy

In recent years, Electroencephalography (EEG) has become an important method for studying the brain's functions shortly after birth. However, working with EEG data from newborns is challenging because data tends to be much shorter due to their limited attentional span, and much noisier due to unpredictable movement artifacts. To the best of our knowledge, there are no specialized tools available for this specific population. As a result, most researchers studying infant development have to manually inspect and clean EEG data, a time-consuming and subjective process that raises concerns about the reliability of their findings.

To address this issue, we have introduced the Newborn EEG Artifact Removal (NEAR) pipeline. NEAR is designed explicitly for handling EEG data from human newborns and consists of two essential components:

1. A novel tool that identifies bad channels in the EEG data using the Local Outlier Factor (LOF), a robust outlier detection algorithm.
2. A method for adapting the parameters of the Artifacts Subspace Reconstruction (ASR) algorithm (developed for cleaning EEG data from mobile adults) to remove artifacts from newborn EEG data.

In this tutorial and hands-on session, I will start by explaining the underlying principles of the NEAR pipeline. Then, we will work with a sample dataset from newborns and walk through the entire artifact cleaning process using the NEAR pipeline. Additionally, I will demonstrate how to fine-tune the user parameters to optimize NEAR for your specific datasets, both for newborn and infant EEG data.

Overall, this approach aims to streamline and enhance the processing of newborn EEG data, addressing the current challenges associated with manual preprocessing and improving the reliability and reproducibility of EEG-based research in the field of infant development.

TALK ABSTRACTS

THURSDAY 19th – Day 4

Effective and functional connectivity analysis of TMS-EEG data

Alberto Pisoni [1]
[1] Department of Psychology, University of Milano-Bicocca, Italy

TMS-EEG co-registration system allows assessing the cortical excitability level of the stimulated brain region and of brain sites that are connected to it. Through the analysis of the spread of the neural signal, indeed, TMS-EEG can reconstruct how and when different cortical sites are communicating. This measure has been related to effective connectivity, since the perturbating stimulus is delivered through a TMS pulse, thus indicating where the signal is coming from. Furthermore, the degree of communication between regions of the cortex starting from the stimulation of a specific region, can differentiate between degrees of consciousness induced by physiologic changes, as during sleep, or pathological conditions, as in disorders of consciousness, as well as external modulations, as in pharmacological anesthesia. Nevertheless, more subtle changes induced by neurophysiologic activations due to cognitive processing may be difficult to capture with such measure. Critically, brain states and cognitive processing have been linked to specific patterns of brain oscillatory activity, analyzed both in the time frequency domain as increases or decreases of power in specific EEG frequency bands, or using functional connectivity measures: when the features shared by two regions on their rhythmic activity are stable over time and trials, a certain degree of communication between the two cortical sites is supposed. There are, however, several different functional connectivity measures, each one with its strengths and weaknesses, and in the TMS-EEG literature, very few examples of the application of these indicators are present. One of the most critical aspects of functional connectivity analyses is the problem of ghost connections or of separating two connections which are near in space. Furthermore, the TMS pulse introduces a strong amount of information in a very specific cortical site, which usually is the one in which researchers are interested into, thus increasing the possibility of highlighting fake connections between the TMS hotspot and neighboring regions due to signal spread. In this presentation, I will show through real data examples, how different acquisition and preprocessing steps of TMS-EEG recordings can influence functional connectivity results, and how different connectivity measures behave with this type of data, with a suggestion of which could be the best suited approach for computing functional connectivity with this technique. Finally, I will report how functional connectivity can be useful in TMS-EEG experiment to track changes induced by external modulations as well as by cognitive processing.

Real-time monitoring of TMS-evoked potentials to improve data quality

Silvia Casarotto [1 2]

[1] *Department of Biomedical and Clinical Sciences, University of Milan, Milano, Italy*

[2] *RCCS Fondazione Don Carlo Gnocchi Onlus, Milan, Italy*

Neuronal responses to stimulation provide useful complementary information to spontaneous brain activity. When sensory pathways are impaired and/or subject's collaboration is unreliable, electroencephalography (EEG) combined with transcranial magnetic stimulation (TMS) represents an ideal tool to investigate brain's reactivity. However, the actual impact of TMS on cortical neurons is currently hard to predict based on a priori biophysical and anatomical knowledge alone. In addition, the nature of TMS brings about special kinds of artifacts, including electromagnetic pulse artifact, unwanted activation of scalp muscles, slow capacitive discharging of charges that accumulate at the electrode-gel-skin interface and spurious potentials evoked by the coil's click and vibration.

Here, we describe a customized software tool labelled rt-TEP (real-time TEP), which interfaces with different EEG amplifiers and offers a series of informative visualization modes to assess the magnitude of the initial brain response to TMS as well as the overall quality of TMS-evoked potentials (TEPs) in real time.

rt-TEP represents a fundamental software complement to any TMS-compatible EEG system because it allows the experimenter to detect the occurrence of artifacts as well as to evaluate the amplitude of TEPs already during data collection. This real-time readout can be used to optimize TMS parameters (e.g., site, orientation, intensity) before data acquisition to obtain TEPs characterized by high signal-to-noise ratio.

Real-time optimization of TMS parameters to achieve a desired level of initial activation can facilitate the acquisition of reliable TEPs and can improve the reproducibility of data collection across laboratories.

POSTER ABSTRACTS

TUESDAY 17th – Day 2

Infants' neural processing of emotional faces is affected by ostracism.

G. Basset, E.Quadrelli, J. Mermier, H. Bulf, C. Turati
University of Milano-Bicocca, Italy

Humans can extract multiple behavioral and biological information from processing others' facial expressions (Leppänen et al., 2007). This ability has been shown to appear at early stages of development (Rayson et al., 2017) and to play a fundamental role in social communication for infants (Kobiella et al., 2008). Many studies have investigated the neural correlates of face processing in infancy (e.g., Leppänen et al., 2007; Kobiella et al., 2008; Quadrelli et al., 2019); however, little is known about whether and how this processing can be affected by social interactions during infancy. The aim of this study is to explore whether being included or ostracized during a triadic playful social interaction (i.e., a ball-tossing game) can influence 13- to 14-month-old infants' behavioral reactivity during the game and the subsequent neural processing of emotional faces. Therefore, we implemented a live version of the Cyberball Game (Williams & Sommer, 1997; Williams et al., 2000) in which infants participated being either included or excluded while playing with two experimenters. The Cyberball phase was videorecorded to assess whether infants' behavior was affected by being ostracized as compared to included. Following the participation in the ball-tossing game, event-related potentials (ERPs) of 38 infants (N = 19 excluded) were measured while they observed faces displaying dynamic expressions of anger, fear, and happiness. Results exploring behavioral reactions revealed that ostracism influenced ostracized infants' negative emotionality and involvement behaviors during the ball-tossing game. Furthermore, analysis on ERP data were conducted via ANOVAs to assess whether the condition in which the infant played the game and the emotional expressions seen had an impact on components' amplitude and latency. Results revealed a faster P1 to happy faces in the ostracism as compared to the inclusion condition. In addition, in the inclusion condition fearful faces elicited faster responses compared to happy expressions, while no significant differences emerged in the ostracism condition. However, no significant results were found for Nc component, considered as an index of the allocation of infants' attentional resources (i.e., Dennis et al., 2009) and for the N290 and P400 components (i.e., linked to face processing, and considered the precursors of adults' N170, de Haan et al., 2003). Current findings demonstrate that ostracism has a direct impact on infants' behavior and influences the way in which they process emotional faces at the neural level, thus suggesting possible negative cascading effects of ostracism episodes on infants' affective and cognitive development.

Impact of Task-Irrelevant Emotional Stimuli on Visual Search

S. Biberci, C. Dolci, C. Della Libera, B. Monachesi, L. Chelazzi
University of Verona, Italy

Attention allows to prioritize relevant information from the environment, while filtering out irrelevant information. Research has revealed that attention can be involuntarily captured by task-irrelevant stimuli (distractors) that are salient for their physical features (e.g., color) or for emotional valence (e.g., negative), leading to impaired performance in visual search. Previous research has shown the possibility of improving our ability to ignore physically salient stimuli through repeated exposure. In view of this learning-dependent mechanism, questions remain about how emotionally salient distractors affect attentional mechanisms and especially whether their distracting power can similarly be reduced through experience. To investigate the attentional capture effect of these two different types of salient distractors, this study introduces a novel experimental design. Participants performed a visual search task involving squares, as in prior studies, and picture stimuli with either negative or neutral valence, as a novel addition. Four stimuli were presented simultaneously in the search display, and participants were asked to find the target stimulus which differed from the others in terms of outline shape. Results showed better performance on distractor-absent trials compared to distractor-present trials. Additionally, emotional valence had a strong modulation effect on RTs, resulting in higher distractor cost in negative distractor-present trials compared to neutral distractor and distractor-absent trials. Despite performance improvement across blocks, negative distractors consistently resulted in higher error rates and longer target detection times. In conclusion, repeated exposure to salient stimuli reduced interference, but negative distractors consistently exert a notably greater impact on performance compared to other salient stimuli.

POSTER ABSTRACTS

TUESDAY 17th – Day 2

Synchronizing with the rhythm: infant neural entrainment to musical and speech stimuli

C. Dondena, M. Borromini, V. Riva, M. Molteni, C. Piazza, C. Cantiani
IRCCS Eugenio Medea, Italy

Neural entrainment is defined as the process whereby brain activity, and more specifically neuronal oscillations measured by electroencephalography (EEG), can synchronize with external (exogenous) stimulus rhythms. Low-frequency (< 6 Hz) neural entrainment has been observed for abstract stimulus properties such as the rhythms of musical beats and linguistic constituents (Nozaradan et al., 2011). Recent theories suggest that individual differences in this phenomenon could be one factor leading to atypical development trajectory of language acquisition (Goswami, 2011). However, despite the importance that neural oscillations have assumed in the last years in the field of auditory neuroscience and speech perception, in human infants the oscillatory brain rhythms and their synchronization with complex auditory exogenous rhythms have been relatively unexplored. The present study aimed to further investigate infant neural entrainment to rhythmic patterns, and specifically to complex non-speech (musical) and speech rhythmic stimuli. Specifically, we performed developmental analyses to explore potential similarities and differences between infants' and adults' ability to entrain to the stimuli and we compared infants from general population with a subsample of infants at higher risk of developing language impairment, i.e. infants at familiar risk (FH+). 36 8-month-old infants (26 from general population and 10 FH+) and 10 adults have been so far included in the study. Their EEG signals were recorded while they passively listened to non-speech and speech rhythmic stimuli modulated at different rates. The temporal envelope of three rhythm patterns was extracted using a Hilbert function implemented in MATLAB and the Fast Fourier Transform (FFT) was applied to compute the spectrum of acoustic energy. FFT was applied to the averaged EEG using Letswave7 (Mouraux & Iannetti, 2008). Neural entrainment to the incoming rhythms was measured in the form of peaks emerging from the EEG spectrum at frequencies corresponding to the rhythm envelope. Analyses of the EEG spectrum revealed clear responses above the noise floor at frequencies corresponding to the rhythm envelope, suggesting that – similarly to adults – infants at 8 months of age were capable of entraining to the incoming complex auditory rhythms. Preliminary results suggest that FH+ infants showed early anomalies in neural synchronization of both music and speech stimuli. Overall, we showed that measures of neural synchronization to complex auditory stimuli are a powerful tool to characterize rhythm perception/synchronization in early (a)typical development. Furthermore, such measures seem appropriate for the investigation of the effect of early music/rhythmic training in infancy (e.g., Dondena et al., 2021).

POSTER ABSTRACTS

TUESDAY 17th – Day 2

Acting jointly is not just acting side-by-side: An EEG hyper-scanning study

M. Fanghella, G. Barchiesi, A. Zazio, A. Battaglia, Mayer, M. Bortoletto & C. Sinigaglia
University of Milan, Italy

Anyone who has ever walked, cooked, or crafted with a friend is in a position to know that acting jointly is not just acting side-by-side. Yet scientific studies on joint action routinely contrast joint with solo action—thereby failing to isolate what is distinctive, among social phenomena, of acting jointly. The present study aims to fill this gap. We used EEG hyper-scanning to investigate whether there are markers of action planning and execution specific to joint action. If so, they should be different when agents plan and execute similar movements in parallel but merely individually. Twenty dyads had to move either one object (Joint-Action Condition) or two objects (Parallel-Action Condition) to a target using a joystick. The tasks were carefully constructed to make coordination challenging in both conditions. We measured two event-related potentials (e.g. CNV and MRP)—as well as alpha-mu rhythm suppression in sensorimotor cortices during motor preparation and execution. We also planned to conduct analyses of inter-brain synchrony. Data hint at reduced CNV and MRP in the Joint- compared to Parallel Action Conditions. Reaction times were also shorter during Joint compared to Parallel Action. This suggests that coordination and mutual adaption are less demanding in terms of self and other representation and monitoring when agents pursue a collective goal. Our study reveals EEG markers of planning and execution that distinguish merely acting in parallel (when this demands monitoring and coordinating another's action) from genuinely joint action.

POSTER ABSTRACTS

Temporal dynamics of size constancy for perception and action with real objects at real distances

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As we watch a train depart from a platform at a railway station, the size of its image on the retina gets smaller as it moves further away from us. Although the train is shrinking on our retina, we perceive it as exactly the same size, but just moving further from us. This perceptual rescaling of size to counteract the natural shrinkage of an object's retinal image with increasing distance is known as size constancy. Size constancy is critical not only to our perceptual experience, but also to our successful interactions with the physical and social world. Yet, our understanding of when and where the complex integration between size and distance information takes place remains unknown. Here, we recorded for the first time event-related potentials (ERPs) in conjunction with kinematics while participants were asked to either manually estimate the perceived size of an object (perceptual task) or to pick it up (grasping task). Small and big disks were placed at near and far distances, respectively, in order to subtend the same visual angle on the retina. Participants were asked to maintain their gaze steadily on a fixation point throughout the experiment. Meanwhile EEG was recorded from 64 scalp electrodes and their hand was tracked with a motion capture system. We focused on the first positive-going visual evoked component peaking at approximately 90 ms after stimulus onset. In the posterior cluster, we found earlier latencies and greater amplitudes in response to bigger than smaller disks, regardless of the task. We also found a later effect of the task, around 130 ms, in a central cluster of electrodes, whereby the P2 mean amplitude was greater in the manual estimation task compared to the grasping. In line with the ERP results, reaction times were faster and mean grip apertures were larger for the bigger objects. These findings demonstrate that size constancy for real objects placed at different distances occurs at the earliest cortical stages and that early visual processing does not change as a function of task demand.

Baseline EEG in the first year of life: insights into the development of autism spectrum disorder and language impairments

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Early identification of neurodevelopmental disorders is critical to ensure a prompt and effective intervention, thus improving the later outcome. Autism spectrum disorder (ASD) and language learning impairment (LLI) are among the most common neurodevelopmental disorders, and they share overlapping symptoms. A number of studies reported an altered spontaneous brain activity in infants at higher likelihood (HL) of developing ASD or LLI (e.g. Benasich et al., 2008; Tierney et al., 2012), thus supporting the hypothesis that an atypical brain development might precede clinical symptoms. The majority of these studies focused only on the analysis of EEG spectral power. However, other EEG derived measures should be investigated for a better understanding of the neural dynamics. Moreover, no previous works have used baseline EEG to investigate early brain development in both HL-ASD and HL-LLI infants altogether. This study aims to: 1) characterize neural activity in 6- and 12-month-old HL-ASD and HL-LLI infants, compared to typically developing (TD) infants, by analyzing EEG spectral power and complexity measures; 2) investigate if the measures associated with risk status are also linked with the later ASD or LLI diagnosis. We recorded 4 minutes of baseline EEG in 302 infants (147 TD, 87 HL-ASD, 68 HL-LLI) at 6 (T6) and 12 (T12) months of age using 60-electrode caps (Geodesic EEG System). We computed: Power Spectral Density (PSD), Detrended Fluctuation Analyses (DFA) and Multiscale Entropy (MSE) focusing on frontal scalp regions. Significant differences between groups were successively tested in subgroups of TD subjects without a diagnosis (N=84) and subjects diagnosed with ASD (N=20) or LLI (N=18). We found risk status for ASD to be associated with reduced power and lower complexity (i.e. decreased long-range temporal correlations (LRTC)) in the low-frequency bands. Whereas, risk status for LLI resulted to be associated with increased power and increased complexity (i.e. increased LRTC) in the high-frequency bands. No differences between groups emerged in relation to MSE, which significantly changed only between T6 and T12. Interestingly, later diagnosis shared similar associations, thus supporting the potential role of EEG derived measures as a biomarker useful for understanding pathophysiology and classifying diagnostic outcomes. Connectivity analysis are ongoing for an exhaustive characterization of brain dynamics and for the identification of the most relevant biomarkers.

Understanding human spatial navigation skills: an EEG study in immersive virtual reality

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Spatial navigation is a complex cognitive process based on multiple senses which denotes the capacity to plan and execute free and goal-directed paths, thus representing an essential ability in daily-life. In this context, EEG alpha and theta frequency bands constitute the most studied oscillations since they have repeatedly been shown to correlate with encoding and retrieval of spatial information (e.g. Bischof et al., 2003) and with sensory, motor, and memory functions, respectively (e.g. Plank et al., 2010). Here, we plan to record EEG signal during a spatial task performed in immersive virtual reality (IVR) in adolescents to investigate the cortical correlates of active spatial navigation. Exploring navigation skills in adolescents is relevant since this is the age when efficient spatial processing is ensured by the fact that allocentric and egocentric strategies operate in parallel (Ruggiero et al., 2016). Moreover, to the best of our knowledge, no previous studies have used EEG in combination with IVR in pediatric population. Twenty healthy youths (age range: 13-18 years) will perform a spatial navigation task in a IVR environment wearing a Oculus Quest and a 32-channel-EEG cap (AntNeuro). The experimental procedure is made of two phases: a training and a test phase. In the training phase (19 trials) the participant navigates through a 5 way maze in a playground trying to learn where a reward is located. During the test phase (8 trails) he has to use the allocentric or egocentric strategy to find the reward. For the EEG data analysis, a trigger will be manually applied at the beginning of each trial and every time the participant takes a new path from the maze centre. The latter will be used to extract event-related epochs in which theta and alpha band power modulations will be analyzed. Since alpha and theta waves are directly related to the storage and retrieval of spatial information for navigation, we expect that theta and alpha activity will be enhanced during the decision-making phase on which path to take. Epochs derived from the test trials will be analyzed separately according to the used strategy (allocentric or egocentric) in order to investigate if the cortical activity is influenced by the adopted strategy. In a second phase, the study will be extended to subjects with cerebral palsy (CP) whose spatial navigation abilities are impaired (Biffi et al., 2020). This will shade light to the neural mechanism underlying navigation problems in patients with CP.

POSTER ABSTRACTS

An integrated EEG and eye-tracking approach for the study of audiovisual sensory processing in infants at elevated likelihood of being autistic

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Background: Autism Spectrum Disorder (ASD) is a heterogeneous condition characterized by atypical social communication and repetitive patterns of behaviour, with recent Italian prevalence estimates of one in 77. The heterogeneity of autism is expressed in individual variation not only in the severity of core symptoms but also in cognitive, language and behavioral skills, which show different developmental trajectories. Moreover, there is a strong interest in identifying reliable behavioral and brain-based predictors, which may constitute useful tools for early detection of at-risk cases. In particular, autistic individuals perform poorly during conditions that require integration across multiple sensory modalities such as audiovisual (AV) sensory integration and process differently social and non-social stimuli compared to neurotypical (NT) counterparts. However, the study of potential interaction between sensory and social processing in the first years of life is still scarce and no study examined early social and sensory markers in infant siblings of autistic children (EL-ASD) using integrated experimental techniques. Objectives: We report a new research protocol that integrates electroencephalographic (EEG) and eye-tracking (pupillometry) measures (1) to characterize AV sensory processing in social and non-social conditions in EL-ASD compared to NT children, and (2) to investigate the association between early social and non-social sensory skills and the clinical outcome measures. Methods and Analyses: The study includes EL-ASD and NT toddlers recruited at 18 months and a follow-up evaluation is collected at 24 months. At both time-points all children are assessed with an experimental protocol including behavioral and neurophysiological measures. The integrated EEG-eyetracking task focuses on AV sensory processing in social (face saying "wow" in infant-directed speech) and non-social (spinning top toy) conditions. Presented videos are presented both in synchronous and asynchronous modalities (1000 ms delay audio presentation). Thus, four conditions are considered (SOC/SYNCH, SOC/ASYNCH, NONSOC/SYNCH, NONSOC/ASYNCH). EEG signal is recorded by EGI High-Density EEG 128-channel system and pupil parameters are recorded using a Tobii ProSpectrum 300 Hz system. In addition, complete information about clinical measures is collected for all children at 18 and 24 months. Data collection is ongoing and preliminary results in 18-month-old EL-ASD and NT children will be presented looking at EEG power and connectivity and at pupil dilation dynamics

The role of aperiodic component in discriminating altered EEG activity in a population of stroke patients

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Background: One of the most common analysis techniques for EEG/MEG signal relies on the estimation of the frequency spectrum. which decomposes the raw signal into putative component oscillations with specific frequencies and expresses the amount of energy associated with each oscillation. Albeit already known since decades, in the recent years literature has witnessed a renewed interest in the so-called “aperiodic component” of the power spectrum. Indeed, beyond oscillations, EEG spectrum also features non-oscillatory activity or broadband 1/f noise, which lacks a predominant temporal frequency and is characterized by an exponent (the slope negativity) and an offset (indicating broadband power shift). Beside methodological implications in interpreting results on frequency bands, there is a growing interest on the potential clinical relevance of aperiodic component of the spectrum: recent studies examined changes in these parameters in various pathologies, from neurodegenerative diseases to stroke and schizophrenia (for a recent review see Pani et al., 2022). Despite this interest, very few have investigated its possible relationship with epilepsy, in particular in symptomatic epilepsy after stroke. Materials and Methods: We analyzed a 19 channel EEG dataset from a group of stroke patients recorded during a resting state paradigm; 19 of them presented EEG with epileptiform activity, even though some of them (N=6) didn’t have any clinical seizure after the stroke onset; the other group (N=26) have no epileptic history nor altered EEG. Using spectral parametrization (specparam, Donoghue et al., 2020) we extracted from each frequency spectrum of each patient the exponent and the offset of the aperiodic component; our goal was to investigate if aperiodic activity could differentiate these two populations, being a potential factor that could help discriminating pathological from non-pathological bioelectric cerebral activity. Results: Both measures significantly differed between the two groups, being more negative in those patients which presented EEG with no epileptic activity . We also investigated if any of them was correlated with three different clinical scales, indicating stroke severity (NIHSS1, NIHSS2 and mRS) but we found no significant relationship. Conclusion: We found some evidence that stroke patients with altered EEG compared to stroke patients with normal EEG activity show difference in aperiodic activity. This effect may be driven by increases in the local excitation/inhibition ratio. These results could pave the way on the use of aperiodic component as biomarker for the development of epileptic EEG activity in stroke patients

Exploring the neurophysiological effects of a visuomotor paired associative stimulation protocol: a TMS-EEG study

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The mirror-Paired Associative Stimulation (m-PAS) is a cross-modal version of the PAS protocol that can induce new ipsilateral motor resonance responses through the repeated association of transcranial magnetic stimulation (TMS) over the right primary motor cortex (M1) paired with the visual presentation of right-hand – i.e., ipsilateral to TMS – index finger movements. Here, we exploited TMS with electroencephalography (TMS-EEG) to clarify the global cortical dynamics underlying its aftereffects. Twenty-five healthy participants underwent the m-PAS protocol. Before and after each m-PAS session, TMS-evoked potential (TEPs) and Motor Evoked Potentials (MEPs) were concurrently recorded during the observation of both contralateral (left) and ipsilateral (right) index-finger movements (or static hands). MEP analysis showed that the m-PAS induced new ipsilateral motor resonance responses, indexed by atypical facilitation of cortico-spinal excitability by the view of ipsilateral hand movements. Moreover, motor resonance was significantly reduced during the observation of contralateral hand movements. Preliminary TMS-EEG analysis showed amplitude modulations of mid-latency M1 TEP components at sensorimotor sites during the action observation task after the mPAS administration. Connectivity analysis will be carried out to evaluate pre-post differences in inter-areal communication patterns. Taken together, the m-PAS protocol effectively reshaped visuomotor representations. This modulation is detectable both at a peripheral (i.e., MEPs) and at a cortical level (i.e., TEPs).

Visual Rule Learning advantage in preverbal infants over adults: evidence from neural entrainment

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Detecting and generalizing repetition-based abstract patterns in continuous streams of information (i.e., Rule Learning, RL) is a key cognitive ability available early in development. The classic approach to investigating infants' RL skills relies on habituation procedures measuring looking times that do not allow the identification of subtle differences in the processing of visual patterns and for comparing the functioning of RL skills across different age groups. To overcome this issue, we investigated visual RL with a new approach by capturing changes in neural entrainment to structures embedded in the input. Thirty-three adults and 31 9-month-old infants were exposed to 2 minutes of sequences of shapes organized into ABA triplets. Each shape was presented at a fixed rate of 6 Hz so that the triplet structure corresponded to a frequency of 2 Hz. The results from Z-scores of the signal-to-noise ratio at the stimulation frequencies (6 Hz and 2 Hz) revealed that the signal was significantly higher than noise already in the first 20 seconds of stimulation (Z-scores > 2.33, Bonferroni corrected), revealing a clear EEG response time-locked to the item frequency (6 Hz) and the frequency of the embedded triplet (2 Hz). Moreover, infants showed a greater EEG response time at 6 and 2 Hz than adults ($p < .001$), suggesting an RL advantage in infants over adults. When comparing the time course of learning, the results showed different learning patterns between adults and infants. Adults showed an increase, while infants showed a decrease in EEG response to 6 Hz ($p < .007$). Contrary, there are no differences in the EEG response to 2 Hz across time between groups ($p > .127$). These results suggest that neural entrainment is a promising tool for exploring how infants' and adults' brains track regularities and structures in the input.

Central and peripheral correlates of negative expectations: toward a new model to explain functional neurological disorders

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Background: Functional neurological disorders (FND) are characterized by one or more symptoms usually of a motor or sensory nature, such as limb weakness, tremor, numbness and dissociative crises, which are incompatible with organic damage or the diseases that typically cause them. Anxiety and stress are considered important factors in the etiopathogenesis of FND. Several studies, in fact, show how the physiological correlates of anxiety and stress are altered in these patients. Through learning phenomena, patients would come to form negative expectations about the nature of sensory and bodily stimuli. Negative expectations, in turn, could fuel physiological anxiety and stress responses in an anticipatory manner. This study aims at developing a deeper understanding of the neurocognitive mechanisms underlying negative expectations in functional neurological disorders. Methods: To this end, electroencephalogram and electrodermal activity (skin conductance responses, SCR) were preliminarily recorded in a group of 10 healthy adults who completed a Pavlovian threat-conditioning task that included an acquisition and an extinction phase. Two Landolt rings with different orientation were presented, one was reinforced with an extremely annoying but not painful short electrical stimulation (CS+) during the acquisition phase, while the other was never reinforced (CS-). We also collected subjective ratings of CSs valence and CS-shock contingency awareness to confirm the successfulness of the conditioning procedure. To get a complete picture of any individual differences in conditioned physiological response, we also assessed the role of personality traits through standardized questionnaires. Results: Here we present preliminary results for subjective ratings and SCR. CSs valence and contingency were coherently recognized by the participants, validating the acquisition and extinction of the threat-conditioning. SCR data provided an additional confirmation of successful conditioning, with greater responses for the CS+ than the CS- during the acquisition phase; the difference between responses to the two stimuli quickly ran out during the extinction phase. Conclusions: These preliminary results confirmed that it is possible to successfully induce threat-learning and negative expectations throughout this specific paradigm, associated with its psychophysiological correlates. The results of this first preliminary phase conducted on healthy adults will be compared with a group of FND undergoing the same paradigm to tackle the question of the role of negative expectations in the pathophysiology of the disorder.

POSTER ABSTRACTS

The role of current direction and pulse waveform on the modulation of an early TMS-evoked potential component

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The combination of transcranial magnetic stimulation with electroencephalography (TMS-EEG) allows to measure TMS-evoked potentials (TEPs) as indices of effective connectivity – i.e., the causal influence of a cortical area over a distant connected area. The development of TEP-derived markers of effective connectivity can be exploited to explore connectivity alterations in psychiatric and neurological conditions. To this aim, a significant challenge is understanding how stimulation parameters, such as the direction of induced current in the brain tissue and the waveform of TMS pulses, impact TEPs. Our study addresses this issue by utilizing an early TEP component (i.e., M1-P15) as an operational model to investigate the role of TMS parameters in the recording of early TEP components, supposed to reflect cortico-cortical connectivity. Indeed, the M1-P15 likely reflects cortico-cortical inhibition in motor areas through the corpus callosum. We conducted a single-session TMS-EEG experiment with 28 healthy participants, manipulating the induced current direction (posterior-anterior, anterior-posterior, latero-medial) and the TMS pulse waveform (monophasic, biphasic) across six experimental blocks. As dependent variables, we measured amplitude and latency of M1-P15. Additionally, we assessed the reliability of M1-P15 across the different conditions using the intraclass correlation coefficient (ICC).

Our results revealed the pivotal role of TMS parameters in evoking the M1-P15, impacting its amplitude, latency, and reliability. Specifically, M1-P15 exhibited the highest amplitude when TMS induced an anterior-posterior current direction with a monophasic waveform compared to other conditions. M1-P15 latency was longer for anterior-posterior current direction compared to posterior-anterior and latero-medial for both monophasic and biphasic waveforms. Finally, the reliability of M1-P15 was poor when stimulation parameters were altered from the ones applied in the original work of our research group on this cortico-cortical TEP component. This further suggests the necessity for controlling these factors to obtain consistent single-subject measurements. Overall, our study underscores the critical importance of considering TMS parameters when recording early cortico-cortical TEP responses. Our findings indicate that modifications in TMS parameters can significantly influence the spatiotemporal characteristics and reliability of early TEP components. This highlights the need for careful attention to stimulation parameters when using TMS-EEG to develop connectivity biomarkers based on TEPs.

Brain connectivity and electrocortical signals related to error processing: a combined TMS-EEG- immersive virtual reality study

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The ability to detect errors in goal-directed actions is quintessential in daily life interactions since, due to their dynamic nature, they often require flexible and adaptable behavior. Error-related negativity (ERN) and error-positivity (Pe) are the two main event-related components linked to error processing, along with fronto-medial Theta band (FMθ; 4-8 Hz) synchronization. ERN is characterized by a negative deflection along the fronto-medial region with a peak around 50-100 milliseconds (ms) after error execution, followed by the Pe, which is mainly related to error awareness and is expressed by a positive peak located around centro-parietal regions. The anterior cingulate cortex (ACC), which plays a crucial role in performance monitoring, has been suggested as the main source of the above-mentioned electrocortical signatures. Notably, previous studies have shown that the observation of errors committed by an embodied virtual avatar (i.e., seen from a first person perspective - 1 PP) has led to the occurrence of ERN, Pe and FMθ synchronization (Pavone et al. 2016). In order for embodiment to take place in an immersive virtual reality environment (IVR), an individual has to control (Sense of Agency - SoA) and perceive (Sense of Ownership - SoO) a virtual body as if it were their own. Interestingly, when an erroneous action is performed by an avatar, individuals seem to experience a transiently feeling of disembodiment with the virtual body (i.e., a reduction in SoO and SoA) which may derive from a potential interaction between the error monitoring network and brain regions involved in Agency and Ownership (specifically frontal and parietal cortices). In the present project we aim at investigating the dynamic interplay between these networks by administering single-pulse Transcranial magnetic stimulation (TMS) over ACC in combination with simultaneous electroencephalography (EEG) recording. ACC activity will be indirectly elicited by stimulating the anatomically connected left dorsolateral prefrontal cortex (dlPFC). 34 healthy participants (two groups: experimental, sham) will engage in an IVR task which requires the observation from a first- or third PP of an avatar performing successful or erroneous reach-to-grasp actions. Effective connectivity changes between ACC (stimulation target area) and remote brain sites will be examined by analyzing TMS-evoked potentials (TEPs) amplitude and changes in FMθ spectral power in the different experimental conditions. Further analyses will focus on the link between ERN, Pe, FMθ modulation and participants' self-reports concerning SoO and SoA, in order to better understand how these electrophysiological markers of error processing relate to behavior.

Familiar rhythmic structures facilitate predictions about upcoming stimuli in the newborn brain

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Neural oscillations are a key neural mechanism in speech perception and language processing in adults (Giraud & Poeppel 2012; Peelle, Gross, & Davis, 2013). However, their role in language processing during early human development is far less well understood. Newborns already show remarkable speech perception abilities. For example, they are able to discriminate languages based on their rhythm behaviorally (Nazzi, Bertoncini, & Mehler, 1998; Ramus et al. 2000). The neural correlates of this ability have also been recently identified: newborns' brain activity differentiates sentences in the native language (French) and a rhythmically similar unfamiliar language (Spanish) from sentences in a rhythmically different unknown language (English) (Ortiz, Guevara, Gervain, 2023). Interestingly, in this study newborns' brain activity increased during the experiment (Ortiz et al., 2023). What causes this increase remains unexplained in this study. The brain has been shown to form predictions about upcoming events (Auksztulewicz et al., 2018; Morillon & Schroeder, 2015). Hence, as speech perception arises from the dynamic sampling of acoustic information at multiple time scales (Morillon & Schroeder 2015), the ability to predict upcoming events may facilitate the encoding of linguistic stimuli (Kujala et al 2023). We thus hypothesize that the increased brain activity observed as sentence presentation unfolded might represent predictions about the rhythmic structure of linguistic stimuli. Consequently, the repeated presentation of the same stimulus may lead to a progressively faster encoding of its characteristics. Indeed, such predictions have been shown to speed up processing of quasi-rhythmic stimuli in adults, resulting in increasingly early response onsets for repeated stimuli termed "precession" (Teng et al., 2020). To test whether this occurs in the newborn brain, we are applying phase precession analysis to the data of Ortiz et al. (2023). After extracting the peak frequency across EEG frequency bands in the first and last sentences presented, we calculate the cross-correlation between the two signals and extract the maximum phase lags for each peak. If no phase precession is present, phases will proceed in 2*pi steps. Otherwise, if phases are accelerated, slopes will be steeper and the delay would be greater than 2*pi (Teng, Larrouy-Maestri, & Poeppel, 2021). We expect to find greater phase precession for the native language and the rhythmically similar unfamiliar language than for the rhythmically different unfamiliar language. This could index the presence of specific predictions regarding the rhythmical structure of speech that guide its encoding, further strengthening the role that rhythm plays in language acquisition already from birth.

POSTER ABSTRACTS

Identification of very early components for TMS-evoked potentials

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Transcranial Magnetic Stimulation coupled with Electroencephalography (TMS-EEG) has emerged as a pioneering approach, providing unprecedented insights into neural signal recording. Current studies employing TMS-EEG coregistration report the generation of TMS-evoked potentials (TEPs) from about 15 ms after the TMS pulse. It is agreed that these TEP components, including the early ones around 15 ms, are generated by secondary activations of distant areas. The advancement of systems for recording TMS-EEG data has brought a better recovery of EEG signals after the TMS pulse. With amplifiers capable of reaching a sampling rate of over 5K Hz it has become possible to reduce the duration of the magnetic pulse artifact to less than 3 ms. This has opened up new perspectives in the analysis of TMS-EEG data, leading to the discovery of early TEP components possibly reflecting the evoked response from the directly stimulated area. In a recently published preprint, the presence of immediate components (2ms after the TMS pulse) has been acknowledged, suggesting that they are cortical responses. Here, we conducted a study to explore the existence of very early components, occurring between 3 ms and 10 ms after the TMS pulse, targeting the motor hand representation in precentral gyrus (M1). Furthermore, we aimed to test the impact of muscle artifacts on detecting these components. In this analysis, we use the data from a previous study conducted in our laboratory. The study included 28 healthy participants who underwent a single-session TMS-EEG experiment in which we varied the current direction of biphasic stimulation, including anterior–posterior-posterior–anterior (AP-PA) and posterior–anterior-anterior–posterior (PA-AP). The EEG signals were recorded at a sampling rate of 9600 Hz, allowing us to estimate the duration of the stimulation artifact to be ~2.5 ms. In this preliminary analysis, we considered only the anterior–posterior-posterior–anterior (AP-PA) direction and obtained average TEPs after minimal signal preprocessing. Next, we divided the subjects into two groups: one where no muscular artifact was detected (noMA), and one with muscular artifacts (wiMA). A very early component, i-TEP, was identified within an interval approximately from 3 ms to 8 ms, similar to the one identified in the preprint study. This component is characterized by a series of peaks, three in most of the cases. These peaks are more prominent on the electrodes close to the stimulation site, with amplitude around 30-40 µV. Interestingly, the i-TEP was evident with similar features in both groups, noMA and wiMA. In the following studies, we will discuss if this component can be considered a cortical response.

POSTER ABSTRACTS

WEDNESDAY 18th – Day 3

The neural correlates of word order in pre-lexical infants: a frequency-tagging approach

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Infants learn their native language quickly and effortlessly and follow the same developmental path regardless of culture. Although infants have an immature peripheral and central auditory system, they show exquisite speech perception abilities from birth. Indeed, the fetus' auditory system is functional by about 150 days after gestation. So, even before birth, they are exposed to the acoustic external environment, which is, however, muffled by the mother's body. According to the "bootstrapping hypothesis" (Morgan and Demuth 1996) infants are able to acquire abstract and structural properties of their language by detecting and using perceptually available surface cues present in the speech input. One of those properties seems to be word order: a pivotal basic element of language acquisition. Indeed, a series of behavioural studies have repeatedly demonstrated that young learners exhibit some knowledge of basic word order from their earliest multiword utterances (Brown 1973; Guasti 2002; Gervain et al. 2008; Bernard and Gervain 2012; de la Cruz et al. 2021). To understand how the surface cues of speech inputs are perceived, neuropsychological and brain imaging works have been conducted in recent years. Their results suggest that language acquisition involves neural commitment (Ahissar et al. 2001; Luo and Poeppel 2007; Buiatti et al. 2009; Ding et al. 2015; Chen et al. 2020): neural phase-locking to speech rhythm seems to track speech comprehension in a reliable way. Using a frequency-tagging approach we aimed to explore the neural mechanisms underlying the perception of word order thanks to the surface cue of the relative position of functors and content words in pre-lexical infants. High-density EEG was recorded in infants of 6 to 8 months of age listening to a monotonous acoustic stream composed of two alternate basic units presented periodically at a specific temporal frequency that mimic the relative frequency of functors and content words in natural languages (aXbY, see Gervain et al. 2008). We hypothesize that the presentation of these structured units, composed of regularly concatenated syllables, would give rise to a peak of power at the frequencies of syllable occurrence. Consequently, if after some exposure, syllables are bound to adjacent syllables and ultimately grouped in quadrisyllabic words, we expected to record a peak of power at the frequency of two or four syllables.

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