PROGETTO 1/ PROJECT 1

Supervisore/*Supervisor*:	Luca Ronconi
Titolo/*Title*:	Aperiodic features of EEG activity and their relevance to perception, cognition, and neurodevelopmental disorders
Corso /*PhD Course*	Scienze Cognitive e Comportamentali
Curriculum:	N.A.
Link alla pagina personale OSR/UNISR/ *Link to OSR/UniSR personal page*:	https://www.unisr.it/docenti/r/ronconi-luca

Descrizione del progetto/Project description (Tra i 2.000 e 3.000 caratteri spazi inclusi/ *Number of characters, including spaces*: 2.000 - 3.000):

Electrophysiological (EEG/MEG) signals are characterized by both periodic and aperiodic properties. Periodic (rhythmic) activity has been widely studied in humans, providing important knowledge on how different brain oscillations support a variety of cognitive functions and how they are implicated in major neurological and psychiatric disorders (Fries, 2023; Ghiani et al., 2021). At the same time, the aperiodic activity, characterized by a 1/F-like distribution where power exponentially decreases as the frequencies (F) increases, has been treated mainly as noise to be removed to better isolate brain oscillations. Recent work has renewed the interest in studying the aperiodic component of neural data, not only to characterize more accurately variations in oscillatory (periodic) activity, but also to investigate the specific neurophysiological substrate of aperiodic components in relation to cognitive and perceptual processes (Donoghue et al., 2020; 2022). Changes in the aperiodic spectrum would reflect alterations in neuronal excitability/inhibition balance (EIB). Initial evidence also suggest that aperiodic activity emerged as an important predictor of individual differences across different cognitive domains (e.g., memory, processing speed, perceptual sensitivity) (Ouyang et al., 2020; Waschke et al., 2021; Thuwal et al., 2021).

This new framework needs empirical support to test whether the aperiodic features of the signal are effectively linked to typical and atypical sensation and perception. The present PhD project aims to test the following questions: 1) is there a relationship between aperiodic features reflecting EIB and perceptual noise?; 2) are there systematic alterations in aperiodic EEG components in neurodevelopmental disorders putatively characterized by different EIB, such as developmental dyslexia (DD) and autism spectrum disorders (ASD)?;

3) are there potential ways to modulate the endogenous or task-related EIB by using transcranial alternating current stimulation (tACS)?

We will test the first hypothesis by collecting new data on a sample of healthy adult volunteers who will undergo a 'perceptual noise exclusion' task in both visual and auditory modalities. The second hypothesis will be tested using datasets of the DoS, that contain both resting state EEG data as well as task-related data collected in samples of children/adult participants with DD or with ASD, along with data of the typically developing age-matched control groups. For the third hypothesis, we will collect new data on a sample of neurotypical adult volunteers, who will be presented with 'perceptual noise exclusion' tasks during the application of a tACS in the alpha or beta frequencies, building on previous evidence suggesting that tACS at these frequencies can modulate the ability to segregate relevant from irrelevant stimuli (Ghiani et al., 2021).

Competenze che deve acquisire lo studente/Skills to be acquired by the student (Max 600 caratteri spazi inclusi/ *Number of characters*, *including spaces*: max 600):

- Planning of experimental designs for behavioral, eye-tracking, tACS and EEG studies
- Data analysis of behavioral, eye-tracking, tACS and EEG experiments
- Advanced statistical analyses of multi-dimensional datasets
- Scientific writing, including eventual preregistration reports, and oral presentation skills
- Critical thinking and critical review of the literature
- Ability to work in a local team and also within an international network

Bibliografia/References (max. 15)

Donoghue, T.; Haller, M.; Peterson, E.J.; Varma, P.; Sebastian, P.; Gao, R.; Noto, T.; Lara, A.H.; Wallis, J.D.; Knight, R.T.; et al. 517 Parameterizing Neural Power Spectra into Periodic and Aperiodic Components. Nat. Neurosci. 2020, 23, 1655–1665. 518 https://doi.org/10.1038/s41593-020-00744-x.

Donoghue, T.; Schaworonkow, N.; Voytek, B. Methodological Considerations for Studying Neural Oscillations. Eur. J. Neurosci. 522 2022, 55, 3502–3527. https://doi.org/10.1111/ejn.15361.

Fries P. Rhythmic attentional scanning. Neuron. 2023 Apr 5;111(7):954-970. doi: 10.1016/j.neuron.2023.02.015.

Ghiani A, Maniglia M, Battaglini L, Melcher D, Ronconi L. Binding Mechanisms in Visual Perception and Their Link With Neural Oscillations: A Review of Evidence From tACS. Front Psychol. 2021 Mar 22;12:643677. doi: 10.3389/fpsyg.2021.643677.

Ouyang, G.; Hildebrandt, A.; Schmitz, F.; Herrmann, C.S. Decomposing Alpha and 1/f Brain Activities Reveals Their Differential 524 Associations with Cognitive Processing Speed. NeuroImage 2020, 205, 116304. https://doi.org/10.1016/j.neuroimage.2019.116304.

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Waschke, L.; Donoghue, T.; Fiedler, L.; Smith, S.; Garrett, D.D.; Voytek, B.; Obleser, J. Modality-Specific Tracking of Attention 542 and Sensory Statistics in the Human Electrophysiological Spectral Exponent. eLife 2021, 10, e70068. 543 https://doi.org/10.7554/eLife.70068.