PADOVA neuroscience CENTER

UNIVERSITÀ DEGLI STUDI DI PADOVA

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AULA MAGNA
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(Via Giustiniani 5, Padova)

PNC SEMINARS

A talk by Camillo Porcaro (University of Padova)

CHARACTERISATION OF BRAIN DYNAMICS AT REST BY FRACTAL DIMENSION

In the last two decades, ongoing brain fluctuations at rest (i.e. in the absence of external stimulation and response demands) have consistently been documented to be organised into large-scale networks, each of them characterised by specific structural and functional architectures. These are known as resting-state networks (RSNs) and have been widely reported in numerous neuroimaging and electrophysiological studies. Furthermore, alterations to RSNs have been observed during healthy ageing as well as in many neuropsychiatric and neurological disorders. Specifically, we aimed to investigate how the neuronal dynamics activity at rest can differentiate RSNs and link them to behavioural and perceptual states. Even though linear methods are predominantly used in characterising brain oscillations in healthy and pathological conditions, linear analysis may not be suitable for describing irregular and non-periodic patterns recorded by electrophysiological and neuroimaging techniques. To this end, we characterised the specific neuronal dynamics signature of each RSN, using a complexity measure called Fractal Dimension (FD) that has advantages over classical linear methods such as the well-known fast Fourier transformation (FFT) that are best suited to conditions where the analysed signals are stationary. FD is a general measure of complexity derived from chaos theory, based on the fact that a simple process repeated endlessly becomes very complex, which is the basis for the description of fractals in nature. Knowing that FD is an accurate numerical measure no matter what the properties (stationary, nonstationary, deterministic, or stochastic) of the analysed signal, it is reasonable to accept this advantage over widely used FFT-based or other linear methods.

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Biography

Camillo Porcaro, PhD, is Associate Professor in Bioengineering at the Department of Neuroscience of the University of Padova. He is a computational neuroscientist with a core interest in developing analytical methods for extracting information from non-invasive measures of brain activity. His research focuses on identifying functional brain sources from data obtained through neuroimaging techniques.

In 2008 he defended with honours his doctoral thesis at the Institute of Advanced Biomedical Technologies (ITAB), University of Chieti, and became a Postdoctoral Fellow at the University of Birmingham – School of Psychology. Then, he joined the Institute of Neuroscience, Newcastle University (2011), and was an Independent Researcher at the Institute of Cognitive Sciences and Technologies (ISTC) – National Research Council (CNR), Rome (2011-2021). He was invited as Visiting Professor at the Neural Control of Movement Lab, Department of Health Sciences and Technology ETH, Zurich, (2014 and 2015), and joined the Department of Information Engineering at the Polytechnic University of Marche, Ancona as Adjunct Professor (2015-2022). He was Visiting Professor at the Department of Human Kinesiology, Movement Control & Neuroplasticity Research Group, KU Leuven (2016-2020) and was Head of the Research hdEEG Lab at S. Anna Institute and Research in Advanced Neurorehabilitation (RAN), Crotone (2018-2021). Since October 2021, he has been appointed Associate Professor at Padua University – Department of Neuroscience.

His most successful contributions have involved source extraction with advanced methods, including Independent Component Analysis (ICA) and a modification of this algorithm called Functional Source Separation (FSS). Furthermore, he developed various temporal and spectral constraints (the basis for FSS algorithms) for extracting and validating primary cortical areas. Recently, he has started applying FSS to EEG data recorded in the MRI environment to improve the quality of EEG data at the individual study level. His recent research focuses on developing functional constraints for the identification of complex cortical networks and the identification of resting-state functional networks (RSN) from EEG and fMRI recordings with the ultimate goal of characterising the neuronal dynamics of these networks using complex nonlinear methods such as Fractal Dimension.