BIOGRAPHICAL SKETCH

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NAME: Bermperidis, Theodoros

eRA COMMONS USER NAME (credential, e.g., agency login): TheoBerbos

POSITION TITLE: Graduate/ Research Assistant

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE (if applicable)	END DATE MM/YYYY	FIELD OF STUDY
University of Patras, Greece	BS	12/2018	Electrical and Computer Engineering
University of Patras, Greece	MS	12/2018	Electrical and Computer Engineering
University of Patras, Greece	MS	09/2019	Biomedical Engineering
Rutgers the State University, NJ	MS	05/2022	Psychology/ Cognitive Psychology
Rutgers the State University, NJ	PHD	09/2024	Psychology/ Cognitive Psychology
Rutgers the State University, NJ	Postdoctoral Associate	-	Personalized Digital Biomarkers Design

A. Personal Statement

I have a passion for discovering the laws of nature and the workings of life, the universe, and the human mind. Early training in Biology and Physics laid out a strong foundation to later combine clinical tools and applied math constructs towards the development of a new generation of highly scalable precision phenotyping toolboxes. I completed an integrated Bachelors and MSc degree in Electrical and Computer Engineering at the Polytechnic School of the University of Patras, Greece and upon graduation I enrolled in the Biomedical Engineering MSc program. Equipped with the ability to mathematically model and analyze human behavioral, imaging and genomic data and with solid knowledge of Biomechanics and the Physiology of the Nervous System I joined Prof. Elizabeth Torres Lab at Rutgers University in the Fall of 2019, as a graduate assistant. I obtained my MSc in Psychology with a focus on Data Science applied to clinical problems in the Spring of 2022 and in September 2023, I defended my PhD combining all this knowledge under the Precision Psychiatry model aimed at advancing the use of Data Science for personalized and population medicine.

I develop new and adapt existing tools from Machine Learning, Statistics, and Information Theory to discover models and laws that govern human neurophysiology and the motor system, from molecules to complex social behaviors. My aspiration is that these tools are deployable at large scale and that the data that they acquire, analyze, and clinically interpret will contribute to the development of technologies that assist in the diagnosis and treatment of disorders of the nervous system as they evolve across the human lifespan. I aim to improve human well-being and overall, the population's quality of life.

B. Positions, Scientific Appointments and Honors

Positions and Scientific Appointments

2023 - Present Have been offered the Nancy Lurie Marks Postdoctoral Fellowship to continue training and publishing my work at the Rutgers Sensory Motor Integration Lab

2019 - 2023 Graduate/ Research Assistant, Rutgers University, School of Arts and Sciences, Departments of Psychology, Sensory Motor Integration Lab, Advisor Prof. Elizabeth Torres, Piscataway , N J

2024-Present Post-doctoral Associate, Rutgers University, School of Arts and Sciences, Departments of Psychology, Sensory Motor Integration Lab, Advisor Prof. Elizabeth Torres, Piscataway, NJ

Honors

2022	Scholarship grant from Gerontelis Foundation, Gerontelis Foundation
2019	Graduate fellowship sponsored by the New Jersey Governor's Council for Autism
2019	Graduate fellowship sponsored by the Nancy Lurie Marks Family Foundation Career Development Award to the PI of the Sensory Motor Integration Laboratory
2013	1st position in the 23nd National Physics Competition , Association of Greek Physicists
2013	Scholarship prize from Eurobank for achieving the highest graduation grade at high school as well as the highest university admission grade, Eurobank Group (Financial company)
2011	4th position in the 21st National Physics Competition, Association of Greek Physicists

C. Contribution to Science

The precision medicine paradigm integrates different levels of inquiry, from genetics and epigenetics to physiological signals and complex social behavior with the goal of developing a systematic platform to diagnose and characterize disorders of the nervous system. However, in the case of autism spectrum disorder (ASD) one-size-fits all models make it hard for researchers to integrate lower levels (genetics) with higher levels (behavior) of inquiry, due to the inherent heterogeneity in neurodevelopmental disorders and the complex relationship between genotype and phenotype.

Throughout my publications [1;2;4], I attempt to integrate gene expression, motor behavior and social interactions and provide an embodied cognition platform for the diagnosis of neurodevelopmental, neurodegenerative, and neuropsychiatric disorders that is personalized and relies on combining clinical scores with numerical data from wearable kinematic sensors, to help us understand how phenotypes and behaviors self-emerge, based on objective biometric data.

Specifically, in [1], I developed a causal model to derive a network that explains interactions between different body parts during a gait task and across optimal time scales, which allowed the stratification of a heterogeneous cohort of the population, thus linking movement patterns to different neurodevelopmental and neurodegenerative disorders, including Parkinson's Disease, ASD, and Fragile X, and to natural aging. The model is a first approach to quantifying re-afference in the nervous system and provides a new definition of motor timing, that unlike older models (inspired from robotics), doesn't pre-impose fixed trajectories and timings.

In [2], I shed light to the origins of neurological and neuropsychiatric disorders by investigating the dynamic trajectory of the human transcriptome through time, from the embryonic stage to full neuronal maturation, by leveraging gene expression data from in vitro validated pluripotent Human Embryonic Stem Cells. By employing statistical independence hypothesis testing, graphical modelling techniques and graph theory I quantified the trajectories of single gene expressions to neuronal fate, the pairwise interactions of any two genes as well as the joint probabilistic behavior of multiple genes. These new frameworks, unlike dimensionality reduction methods (such as PCA and t-SNE) which were adopted in gene analysis from computer vision and disregard over 90 % of genes to cluster cells, considers the role of all genes, including the ones that minimally express to characterize their role in each disorder. In [3], I applied these methods to interrogate the human transcriptome and uncover the roles of a subset of genes associated with brainstem disorders. This work is still in progress along with work related to the mouse transcriptome, presented at the Society for Neuroscience in San Diego, CA, 2022.

Finally, in [4], I redefined socio-motor agency to be the balance between control and autonomy, for the basic unit of social interactions, the dyad. The new methods were implemented using data from wearable kinematic sensors strapped on body parts of children and clinicians during clinical sessions of the Autism Diagnostic Observation Schedule (ADOS). The concept of motor control was adopted from the framework of standardization of human motion developed by Prof. Elizabeth B Torres, while autonomy was defined using the concept of entropy rate from information theory to quantify randomness vs. predictability, under the hypothesis that predictable agents are more controllable and less autonomous in a dyadic interaction. The hypothesis was validated, by comparing entropy rates and causal interactions between children and clinicians, the latter were estimated by using the information theoretic measure of transfer entropy. A classifier was built and tested against overfitting to assist diagnosis of autism in the context of ADOS and identify tasks that maximally separate ASD from the normative control group. The new digitally streamlined ADOS can be a valuable tool for clinicians to reduce the time length of ADOS sessions and choose tasks that are more suitable for the diagnosis of females, who generally mask symptoms of autism better than males.

I'm currently working on on-line tracking of face expression, either within the context of social interactions or during solo instructed imitation of the seven universal face expressions (with the goal of a novel characterization of facial activation in autism and neuro-divergence in general), using state of the art multidimensional tools from information geometry and dynamical systems.

1. Bermperidis T, Rai R, Ryu J, Zanotto D, Agrawal SK, Lalwani AK, Torres EB. Optimal time lags from causal prediction model help stratify and forecast nervous system pathology. Sci Rep. 2021 Oct 22;11(1):20904. PubMed Central PMCID: PMC8536772.

2. Bermperidis T, Schafer S, Gage FH, Sejnowski T, Torres EB. Dynamic Interrogation of Stochastic Transcriptome Trajectories Using Disease Associated Genes Reveals Distinct Origins of Neurological and Psychiatric Disorders. Front Neurosci. 2022;16:884707. PubMed Central PMCID: PMC9201694.

3. Torres, E. B., Bermperidis, T., Varkey, H., Vero, J., London, E., Phan, H., ... & Sejnowski, T. (2022). Sensing Echoes: Temporal Misalignment as the Earliest Marker of Neurodevelopmental Derail. *Available at SSRN 4049202*.

4. Bermperidis, T., Rai, R., & Torres, E. B. (2023). Digital Screener of Socio-Motor Agency Balancing Autonomy and Control. *medRxiv*, 2023-10.

Provisional Patent

RU 2024-006 15290-036US0 20230908, to USPTO: Techniques for measuring or modifying control in digital interactions.

Conference and Workshops Presentations

1. "Dynamic Interrogation of Stochastic Transcriptome Trajectories Using Disease Associated Genes Reveals Distinct Origins of Neurological and Psychiatric Disorders", Talk (By invitation only) at Information Theory and Applications Workshop, 2022, San Diego, CA

2. "New Computational Methods of Dynamic Transcriptome Interrogation to Study Neurodevelopmental Motor Disorders of the Autism Spectrum in Human and Mouse Embryonic Stem Cells", Society for Neuroscience, 2022, San Diego, CA

3. "Novel statistical platform offering Interpretable objective biometrics, machine learning and AI tools for personalized diagnosis and treatments of neuromotor control disorders", Society for the Neural Control of Movement (N CM), 2023, Victoria BC, Canada

Services

Since my publication in Scientific Reports and Frontiers in Neuroscience, I have been called multiple times to serve as reviewer of computational models in these journals. Furthermore, I officially serve as regular reviewer in IEEE.

Ad Hoc Reviewer for Scientific Reports, the Open Access Journal of Nature Publishing Group.

Ad Hoc Reviewer for Frontiers in Neuroscience

Reviewer for IEEE.

Besides my editorial work, I also served at the New Jersey Autism Center of Excellence from 2019-2023 helping with conference organization, data interpretation and dissemination of scientific knowledge in lay terms.

Programming and software skills

Matlab: Signal Processing Toolbox, Simulink, Statistics and Machine Learning Toolbox, Graph and Network Algorithms, Deep Learning Toolbox, Symbolic Math Toolbox, Parallel Computing Toolbox, Image Processing and Computer Vision Toolbox, Audio Toolbox, Fuzzy Logic Toolbox, SPD toolbox

R: pcalg toolbox (Causal Discovery Toolbox), stats package, PGAN toolbox (Generative Adversarial Nets), Bioconductor package (open source software for Bioinformatics)

Python: PyTorch, NetworkX (for network analysis), GUDHI (for topological data analysis), pygame (for multimedia applications, e.g. games)

Java: Java Information Dynamics Toolbox (JIDT), Javaplex (toolbox for topological data analysis, can be used from Matlab)

Prolog

Basic knowledge of C, C++ and Assembly

AutoCAD

Adobe Illustrator

Audacity (audio processing software)

Flowchart editors

Blender (3D computer graphics software)

OpenFoam (computational fluid dynamics toolbox)

CoppeliaSim (robotics simulator)

Latex

Word/ Excel and other basic tools

Practical mathematical skills

Basic knowledge: Analytical and Differential Geometry, Linear algebra, Vector Spaces, Real and Complex Analysis, Discrete Mathematics, Abstract Algebra, Graph Theory, Multivariate Calculus, Measure Theory, Ergodic Theory, Probability Theory, Mathematical Statistics, Elementary Algebraic Topology, Numerical Analysis, Algorithms and Complexity Theory, Mathematical Logic and Set Theory

Signal Processing and Time Series Analysis: time and frequency domains analysis, image processing and computer vision, forecasting, causal inference, parametric and non-parametric modelling, system identification

Applied Statistics: hypothesis testing, statistical inference, parametric and non-parametric statistics, Bayesian statistics, discrete and continuous stochastic signals and systems, non-parametric tests of independence, kernel methods, regression

Data Science: machine learning methods for classification and clustering, deep learning, Generative Adversarial Networks, fuzzy logic and analysis, data embedding, Topological Data Analysis (TDA) with applications to bioinformatics, tensors

Network Science: graph theory, random graphs, spectral methods, graph signal processing, (causal) graphical models with applications to gene expression or biosensor time series networks

Information Theory: Shannon information theory, data compression, coding theory, statistical estimation of entropy, mutual information and entropy rate, Information Geometry, applications to dynamical systems (e.g. information dimension and phase space reconstruction)

Dynamical Systems: dynamical systems modelling, state space analysis, linear (non-linear) dynamical systems and chaos, phase space reconstruction, continuous and discrete systems, entropy rate (randomness) for dynamical systems

Biomedical Engineering Knowledge and Skills

Physiology/ Anatomy/ Biochemistry (theory)

Biomechanics/ Biofluid Mechanics

Electronics and Digital Signal Processing in Medicine

Medical Instrumentation and Imaging/ Bioelectromagnetism

Biomaterial and Tissue Engineering (theory)

Biomedical Signal Processing

Biostatistics

Languages (besides English) and Other Skills

Fluent in Greek

Upper Intermediate French (B1, B2 certified profiency)

Basic Knowledge in Theory of Music