## 7th BigBrain Workshop: Challenges of big data integration



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## SynthEco: A digital system for analyzing the brain-to-society mechanisms of lifecourse human behavior in its multi-layered and dynamic environment and its mental health and well-being consequences

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Biological, social, cultural and economics factors are important determinants of health/disease status and wellbeing throughout life. We are presenting the open-source ecosystem "SynthEco" which utilizes statistically representative synthetic populations derived from census data for a given geospatial granularity to create a complex digital ecosystem to analyze the brain-to-society pathways of lifecourse human behavior within their environment, zooming in on dopamine gene and brain systems as key biological bridge. In this context, we are introducing a way of parameterising and re-parameterising individuals through a combination of genomic, health as well as behavioural and social data, using a geospatially referenced synthetic population as merging layer. Through the geospatial layer the individuals are also anchored into context such as surrounding infrastructure and social environment, allowing for the analysis of individuals'multidimensional behaviour and health outcomes over time while considering the context they are acting within, such as through the use of agent-based models or simulation studies.

Taking Montreal (Quebec, Canada) as development and Pittsburgh (Pennsylvania, USA) as replication side, we enrich a synthetic population through linkage and statistical extrapolation with longitudinal geo-referenced discovery (MAVAN; birth cohort) and population (CLSA; Canadian Longitudinal Study of Aging) cohorts. We trace molecular pathways through which dopamine-related genes in specific brain regions related to decision-making, emotional regulation and behavior may act in concert to shape mal/adaptive responses to the environment (expression-based polygenic risk scores based on the DRD4 co-expression gene network in the striatum (ePRS-DRD4)). The SynthEco platform views individuals as agents nested within modular systems of systems, which includes those operating at multiple scales in their biology and their psychology, as well as systems of a different type that form their multi-layered environment (e.g., birth weight, early child/family environment, area-level socio-economic status, access to affordable school, housing, transportation, food, as well as access to local social and health services in the form of enterprises and institutions).

The longitudinal cohorts and cross-sectional studies in SynthEco cover different aspects of human behavior, food security and financial, physical and mental wellbeing over the life course which are assessed at different age point along a lifecourse continuum (childhood, adolescence, young adult, aging adult). The time-sensitive re/parameterization of agent's behavior made possible by stitching together information from different data bases in SynthEco opens new possibilities for allowing the consideration of the complex, multi-faceted behavior of these agents as they evolve in space and time. These combined data sources allow for the geospatial clustering of different dimensions of health and wellbeing in individuals and the identification of vulnerable groups sharing similar risk profile characteristics and environmental conditions, which could inform the development of targeted public health interventions and community planning, as well as better targeted public policy and investment.

Implications of this work are of interest to researchers modeling complex human behavior and agent-based models, as well as governments, policymakers, and NGOs interested in simulating interventions, analyzing individuals within a population, and identifying sub-populations or regions of specific concern to them.

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