SCIENCES & BIOENGINEERING SCIENCES

The Research Group
Artificial Intelligence Lab

has the honor to invite you to the public defence of the PhD thesis of

Steven Thomas Homer

to obtain the degree of Doctor of Sciences

Title of the PhD thesis:

Foundations of the Information Dynamics of Thinking

Supervisor:
Prof. dr. Geraint Wiggins

The defence will take place on
Thursday, December 11, 2025 at 4 p.m.

VUB Etterbeek campus, Pleinlaan 2, Elsene, in Promotiezaal D.2.01

The defence can be followed on live stream:
Public PhD Defense on Microsoft Teams

Members of the jury

Prof. dr. Beat Signer (VUB, chair)
Prof. dr. Ann Dooms (VUB)
Prof. dr. Nikolaos Deligiannis (VUB)
Prof. dr. Elisa Gonzalez Boix (VUB)
Prof. dr. Bart de Boer (VUB)
Prof. dr. Edward W. Large (University of Connecticut, USA)
Prof. dr. Antonio Chella (University of Palermo, IT)

Curriculum vitae

Steven T. Homer (°1989) obtained his BSc degree (Dean's Honor List) in 2012 from the University of Wisconsin - Madison with a double major in Computer Engineering and Computer Science. In 2019, he obtained his MSc degree (Greatest Distinction) from Vrije Universiteit Brussel in Computer Science, specializing in Artificial Intelligence. He then joined the Computational Creativity Lab in the AI Lab at VUB as a PhD student and teaching assistant in 2019, funded by the Flanders AI Research Program. By the end of his PhD, his research and collaborations resulted in two first-author publications in international peer-reviewed journals as well as five conference papers.

Abstract of the PhD research

The senses are our only means of receiving information from the outside world, yet we possess an inner world full of meaning and emotion. How does the semantic richness of cognition emerge from meager perception? The Information Dynamics of Thinking (IDyOT) is a theoretical cognitive architecture that specifies how a deep hierarchy of cognition is built from the substrate of perception using a minimal set of mechanisms. These mechanisms act upon spectral knowledge representations (SKR) and are guided by information dynamics. Unfortunately, sufficiently general mathematical formalisms that satisfy the requirements of SKR and information dynamics have remained open questions. In this work, I present resonance spectral knowledge representation and contrast information dynamics as the foundations of IDyOT.

From quantum mechanics to musical acoustics, the phenomenon of resonance occurs throughout nature whenever a system oscillates according to its natural frequency. I suggest that resonance alone accounts for the totality of mental representation, where meaning is explained by relations within and between resonance spaces. I show that resonance spaces model aspects of music perception, such as musical key affinity and interkey distance. Angles and distances between structures in resonance spaces correspond to the empirically perceived similarity between musical concepts. In practice, resonances allow us to circumvent the Fourier uncertainty principle, resulting in high resolution spectral analysis. To this end, I present the discrete resonance spectrogram, a succinct and clear visualization of a signal's spectral structure. Beyond IDyOT theory, the resonance methodology has broad applications throughout signal processing and spectral analysis.

The information dynamics of perceptual stimuli are not only evident in neural activity, but also manifest in psychological phenomena such as expectation and uncertainty. In the same way that the temperature itself remains unchanged whether you use Fahrenheit or Celsius, in order to measure information dynamics, the information associated with continuous stimuli must be independent of the coordinate system. I present contrast information as a coordinate-invariant, dynamic information measure that applies uniformly to both discrete and continuous processes. I then derive the temporal variants of contrast information to measure such properties as the predictability, Markovity, and determinacy of a specific sequence at specific points in time. Beginning from first principles, I use these variants to derive liminal contrast, a quantity that signals the information-theoretic segmentation of sequential data. Beyond IDyOT theory, the contrast information framework can be applied more broadly in time series analysis, statistical modeling, and machine learning.