All you ever wanted to ask about Dynamic Field Theory

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How does the mind emerge from the brain?

A neural process theory of cognition is one of the central goals of cognitive science. Connectionism, developed in pursuit of that goal, led to a range of proposed frameworks such as LISA and DORA (Doumas, Puebla, Martin, & Hummel, 2022), SPAUN (Stewart & Eliasmith, 2012) and many others (Kotseruba & Tsotsos, 2020). The rise of neural AI reframes the question of how neural accounts may reach higher cognition (Smolensky, McCoy, Fernandez, Goldrick, & Gao, 2022; O'Reilly, Ranganath, & Russin, 2022).

But what is meant by neural process theory ? Which neural principles would form the basis for such a theory? And what is it a theory of? What properties of cognition must such a theory address?

Dynamic Field Theory (DFT) gives specific answers to these questions, postulating that the dynamics of neural populations are the level of neural processing that most closely reflects the laws of cognition. It emphasizes the emergence of cognition from the sensory-motor domain, so that a theory of cognition must address both acting and thinking.

The development of DFT reflects this hypothesis: It started out with sensory-motor decision making over 20 years ago, but has only recently begun to address higher cognition (Sabinasz, Richter, & Schöner, 2023). The somewhat demanding mathematical technology of DFT has been the focus of previous tutorials at CogSci. Progress in DFT makes another challenge acute: DFT accounts for many different competences ranging from motor control (Schöner, Bildheim, & Zhang, 2024) and attention (Grieben et al., 2020) to visual working memory (Buss, Magnotta, Penny, Schöner, & Spencer, 2021), cognitive control (McCraw et al., 2024), and word learning (Bhat, Spencer, & Samuelson, 2022; Spencer, Buss, McCraw, Johns, & Samuelson, 2025). These are studied in many different sub-disciplines with different methods, concepts, and experimental questions, making it difficult for researchers in any specific area to understand and assess DFT.

Goal of the tutorial

This tutorial is aimed to address this challenge. Rather than introduce DFT from scratch, we plan to organize the tutorial around questions that different communities typically pose when confronted with DFT. We aim to generate structured dialogue with the audience, adjusting to their needs and reacting to their interests. This idea to drive a tutorial by questions arose from demands of the audience at previous workshops and tutorials (most recently at Psychonomics 2024).

Tutorial organizers

Gregor Schöner holds the chair for Theory of Cognitive Systems at the Institute for Neural Computation (INI) of Ruhr-University Bochum (RUB) in Germany. With a background in theoretical physics, he has pursued an interdisciplinary theoretical approach to problems in human movement, visual psychophysics, grounded cognition, autonomous robotics, and computer vision to understand how cognition emerges from its sensory-motor foundations. He has held academic positions in the US, France, and Germany, has been funded through German, French, European, and US funding agencies, and has published over 270 scientific articles.

Yulia Sandamirskaya is heading the Research Centre Cognitive Computing in Life Sciences at the Zürich University of Applied Sciences (ZHAW). Her group develops neural-dynamics based cognitive architectures for real-time, embedded AI systems, spanning sensing, planning, decision making, learning, and control for the next generation of assistive robots. She obtained a diploma in physics from the Belarusian State University, and a doctorate in physics from the Ruhr-University Bochum (RUB). She was a group leader at the INI of RUB and group leader and lecturer at the Institute of Neural Computation of the ETH Zürich/University Zürich. At Intel Labs, she was an Application Research Lead and a Venture Lead, before joining ZHAW.

Aaron Buss is an Associate Professor of Psychology at The University of Tennessee, Knoxville. He received a B.S. from North Central College in 2007 and a Ph.D. in Psychology from The University of Iowa in 2013. He is recipient of the D. C. Spriestersbach Dissertation Award from the University of Iowa. His research examines executive function and brain-behavior relationship across the lifespan. He is also trail-blazing the analysis of neural imaging data based on neural dynamic models. His research is funded by NIH.

Structure of the tutorial

What is DFT? To set the stage, Gregor Schöner will first lay out five theoretical commitments of DFT: (1) the connectionist foundation: activation, sigmoids, connectivity; (2) spaces and fields; (3) neural dynamics and attractors; (4) dynamic instabilities and autonomy; (5) binding through coupling.

What is meant by "neural process theory"? A first discussion block will be animated by Yulia Sandamirskaya around questions such as: Why dynamics? Why attractors? Are not all neural processing transient? Why continuous spaces? In which sense are neural fields low-dimensional? Why are neural representations in DFT localist? How does DFT generate discrete processing steps?

How is DFT related to other neural theories? Aaron Buss will lead the discussion that directly compares DFT to other neural process accounts of cognition around questions like these: Why neural populations? How are neural fields related to the high-dimensional/distributed representations that drive much of current neural AI? Why not use spiking NN? Is there a one-to-one mapping of DFT models onto the brain? How about degeneracy of neural function? How is processing in DFT related to the computational cycles of transformer networks? How is learning in DFT different from learning in connectionism and neural AI?

What is DFT a theory of? What is cognition? Finally, Gregor Schöner will lead a discussion on embodied vs. higher cognition: Are autonomous embodied and situated agents representative of cognition? In which sense is thinking like acting? Is cognition computation? How does DFT address computation? Do notions of higher cognition like compositionality and productivity make sense in DFT? How is DFT addressing metaphor, the notion that is central to the embodied perspective on cognitive linguistics. Are there any truly categorical representations in DFT? Are fields modules? Could DFT models be described by ACT-R? How is binding addressed in DFT vs. in VSA vs. in transformer networks?

Preparation

The tutorial will not introduce DFT in a technical sense. Participants are encouraged to familiarize themselves prior to their attendance with the basic notions of DFT using material made available through the web page `https://dynamicfieldtheory.org/events/cogsci2025/`.

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