



Neurosalience Podcast

Bringing It All Together

Peter Bandettini, Ph.D.

OHBM 2026 DISCLOSURES

I have no conflicts of interest in relation to this podcast to disclose.

Guests



Satra Ghosh, Ph.D.

Director of Open Data in Neuroscience Initiative and Senior Research Scientist at the McGovern Institute for Brain Research at MIT



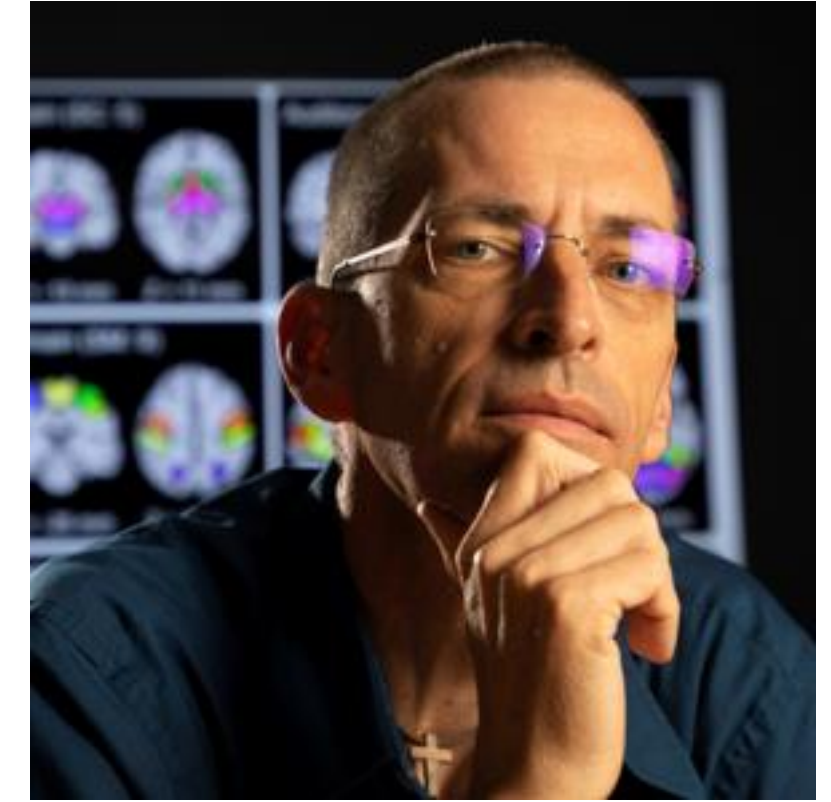
Mario Senden, Ph.D.

Assistant Professor, Faculty of Psychology and Neuroscience, Maastricht University, The Netherlands



Giulia Baracchini, Ph.D.

Post doc with Mac Shine
University of Sydney



Vince Calhoun, Ph.D.

Founding Director of the Center for Translational Research in Neuroimaging and Data Science (TReNDS) at Georgia State University, Emory University and Georgia Institute of Technology

The Challenge

How to bring it all together?

- **Neuroscience research is fragmented and siloed** by domains, scales, and modalities. Results are mostly self-contained and **disconnected**.
- **We are overwhelmed** with data and literature - too much to absorb. Talks or posters at meetings and papers are heard or read by only a fraction who might benefit from the results. This is far from optimal. No one individual or group can even begin to keep up with. We need to **curate and connect or relate** it all to build insight as well as perspective on the advances, opportunities and gaps.

Solutions?

Tools and Models

- **Data across scales and domains need to be integrated.**
- **Tools** that connect and relate **raw data** across domains, scales, and modalities need to be built and their use incentivized. **Mechanistic Models** that span spatial and temporal scales need to be grown, tested, and iteratively refined. These models need to complement the growth of **Theoretical Frameworks**.
- **Tools** that incorporate and curate **reported findings** to provide added perspective and insight need to be built and their use incentivized. The **literature needs to be integrated and mapped** through relationships within and across domains, scales, and modalities.

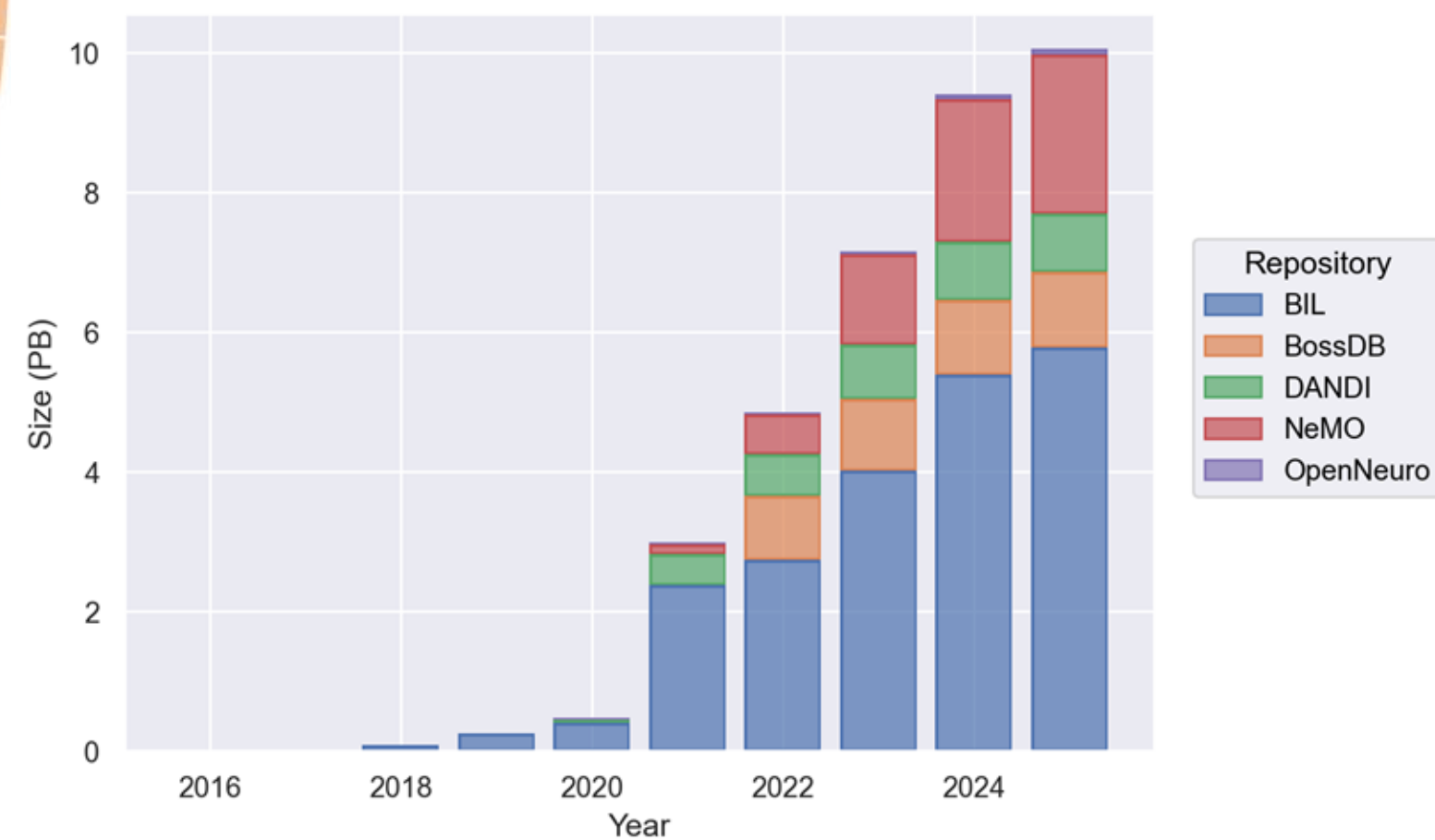
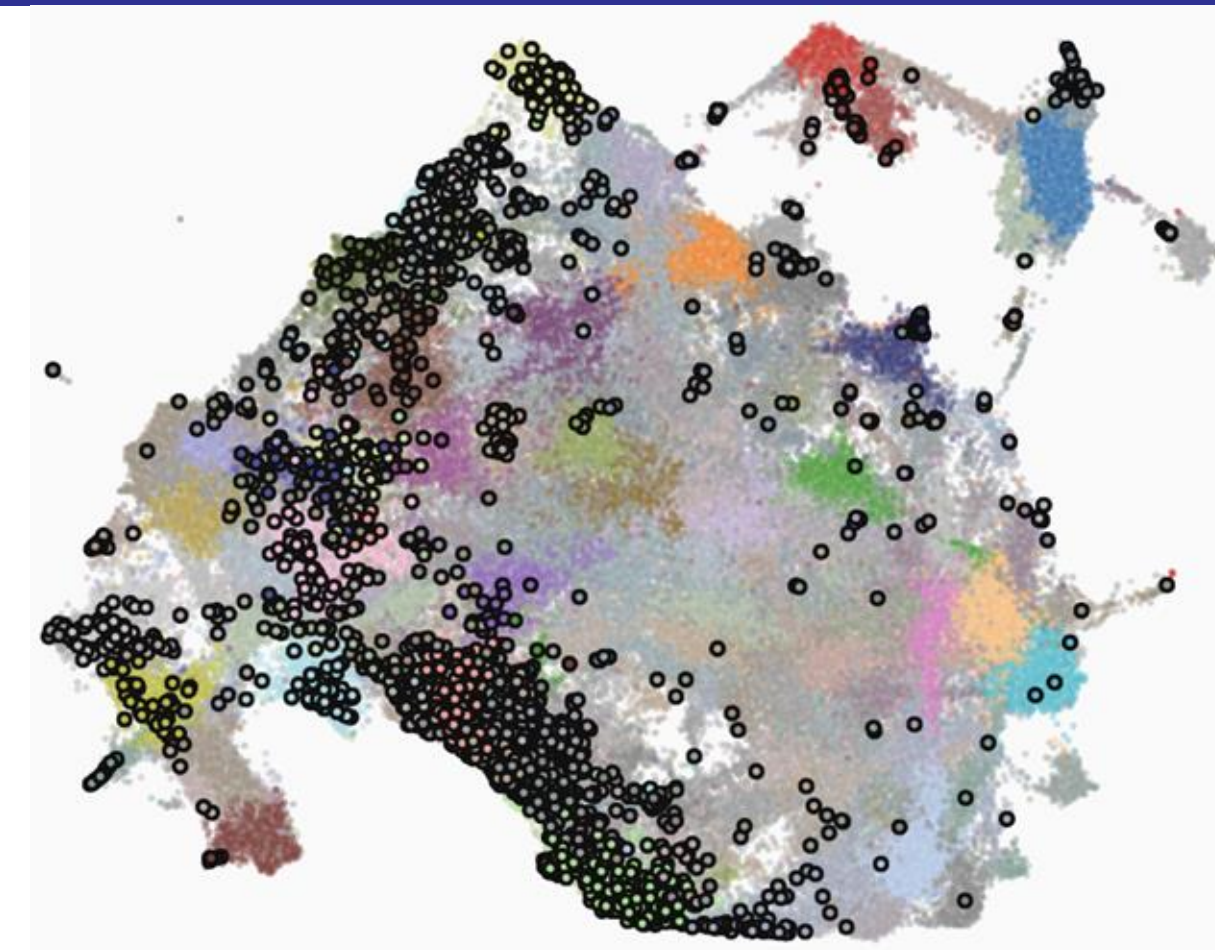
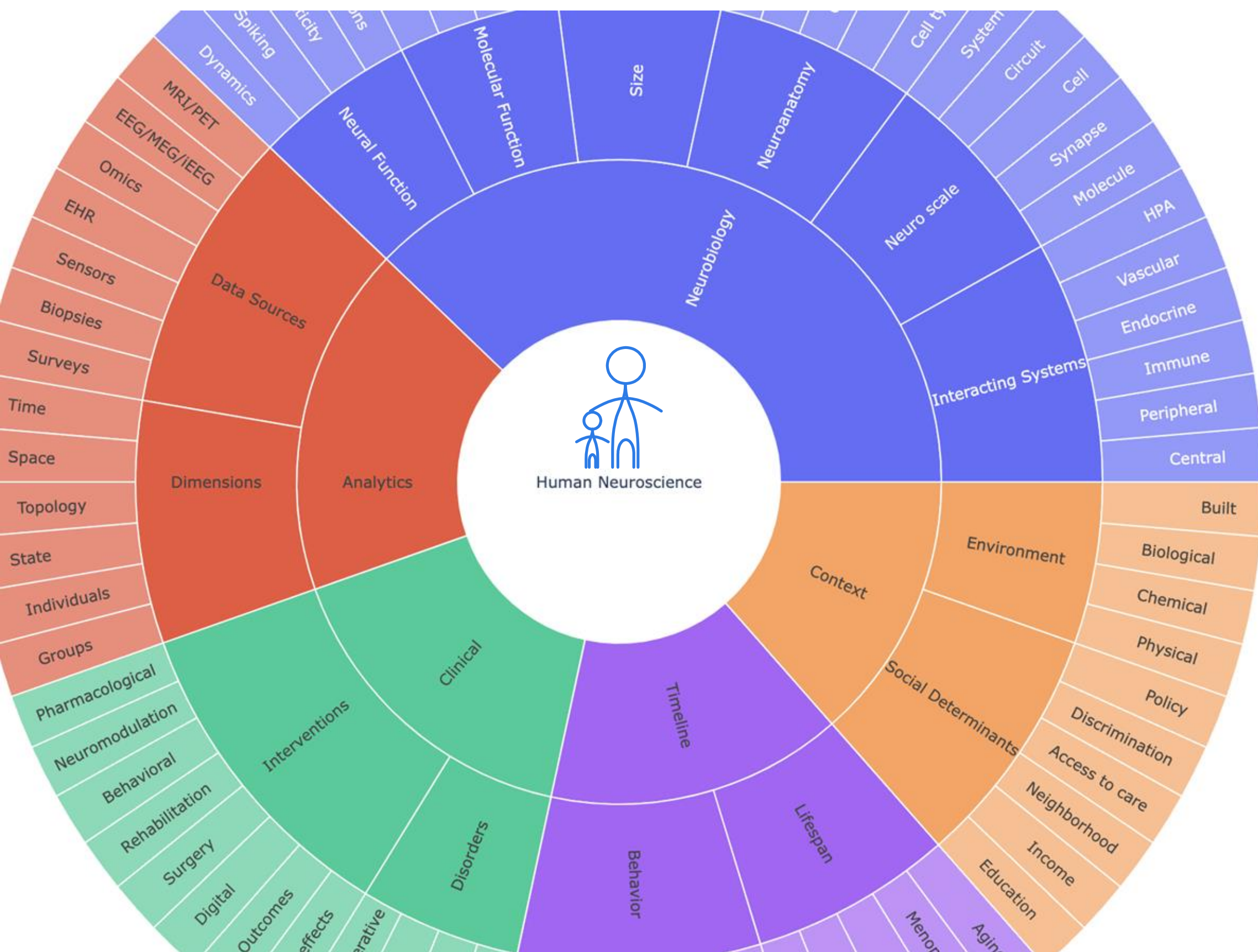
S. S. Ghosh, “An intelligent infrastructure as a foundation for modern science.”
ArXiv <https://doi.org/10.48550/arXiv.2508.10051>



Satra Ghosh, Ph.D.

**Director of Open Data in
Neuroscience Initiative and
Senior Research Scientist at
the McGovern Institute for
Brain Research at MIT**

Data across the neuroscientific landscape



Frictionless Reproducibility

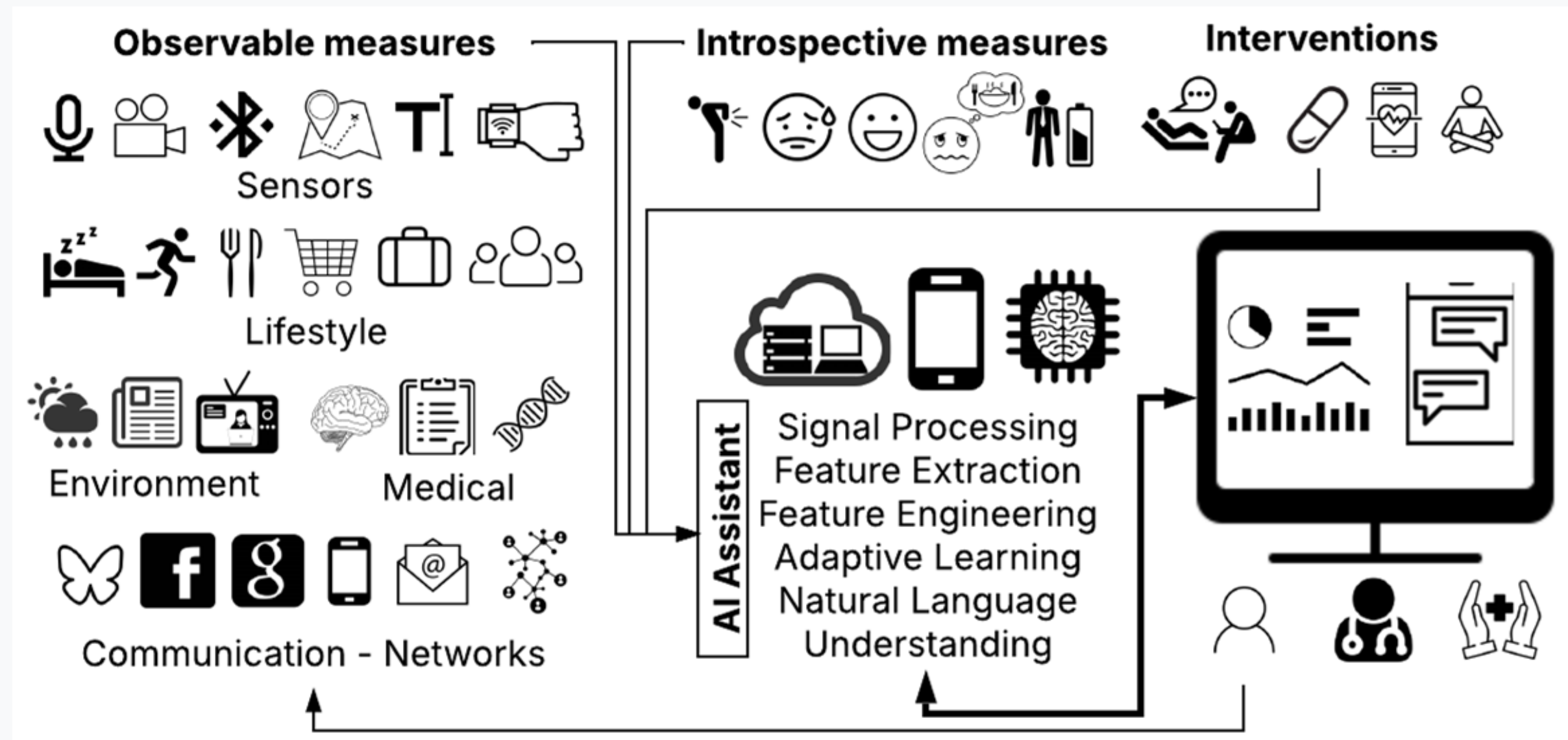
In a 2024 Harvard Data Science Review essay, David Donoho introduced "Frictionless Reproducibility" (FR) as a key accelerator of "computation-based research," observing Empirical Machine Learning's (EML) progress through three characteristics:

[FR1] Data Resources

[FR2] Low Barriers

[FR3] Platforms

These factors are sociotechnical in nature, representing a threshold of "Singularity" that has allowed EML to advance rapidly.



**M. Senden, “The evolving landscape of neuroscience” Aperture
Neuro, 6: SI 2, 2026 <https://doi.org/10.52294/001c.156380>**



Mario Senden, Ph.D.

**Assistant Professor, Faculty
of Psychology and
Neuroscience, Maastricht
University, The Netherlands**

The Evolving Landscape of Neuroscience

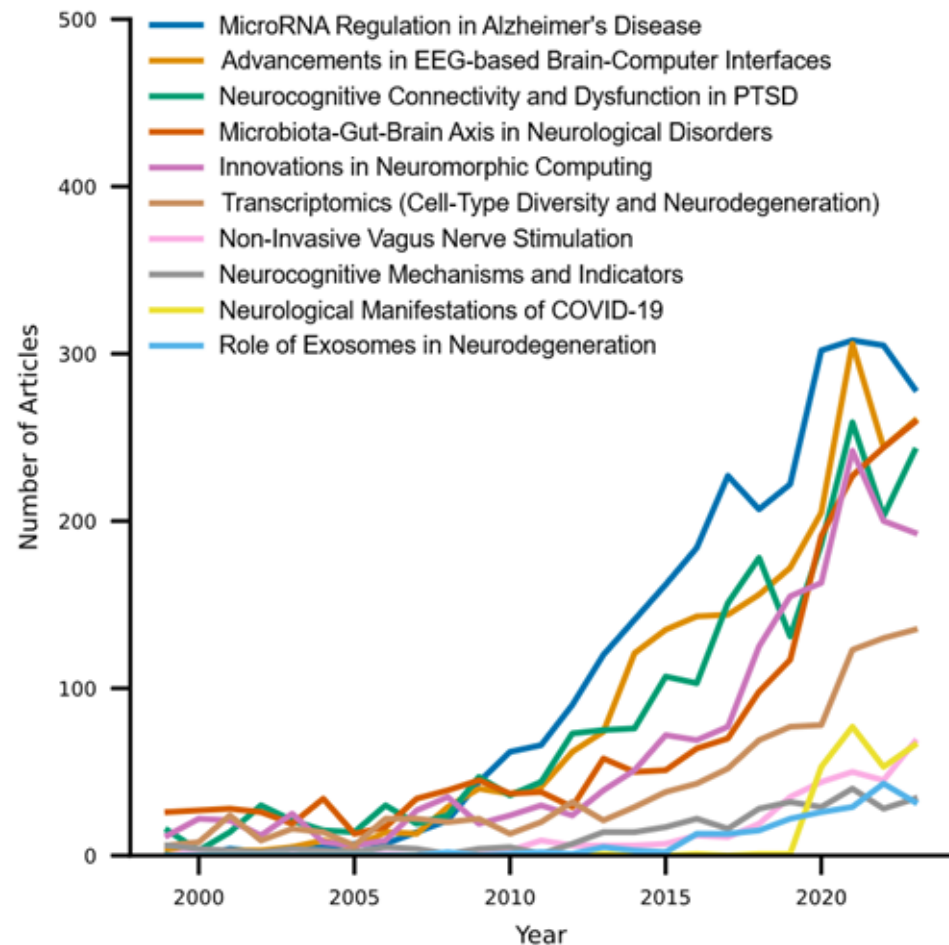
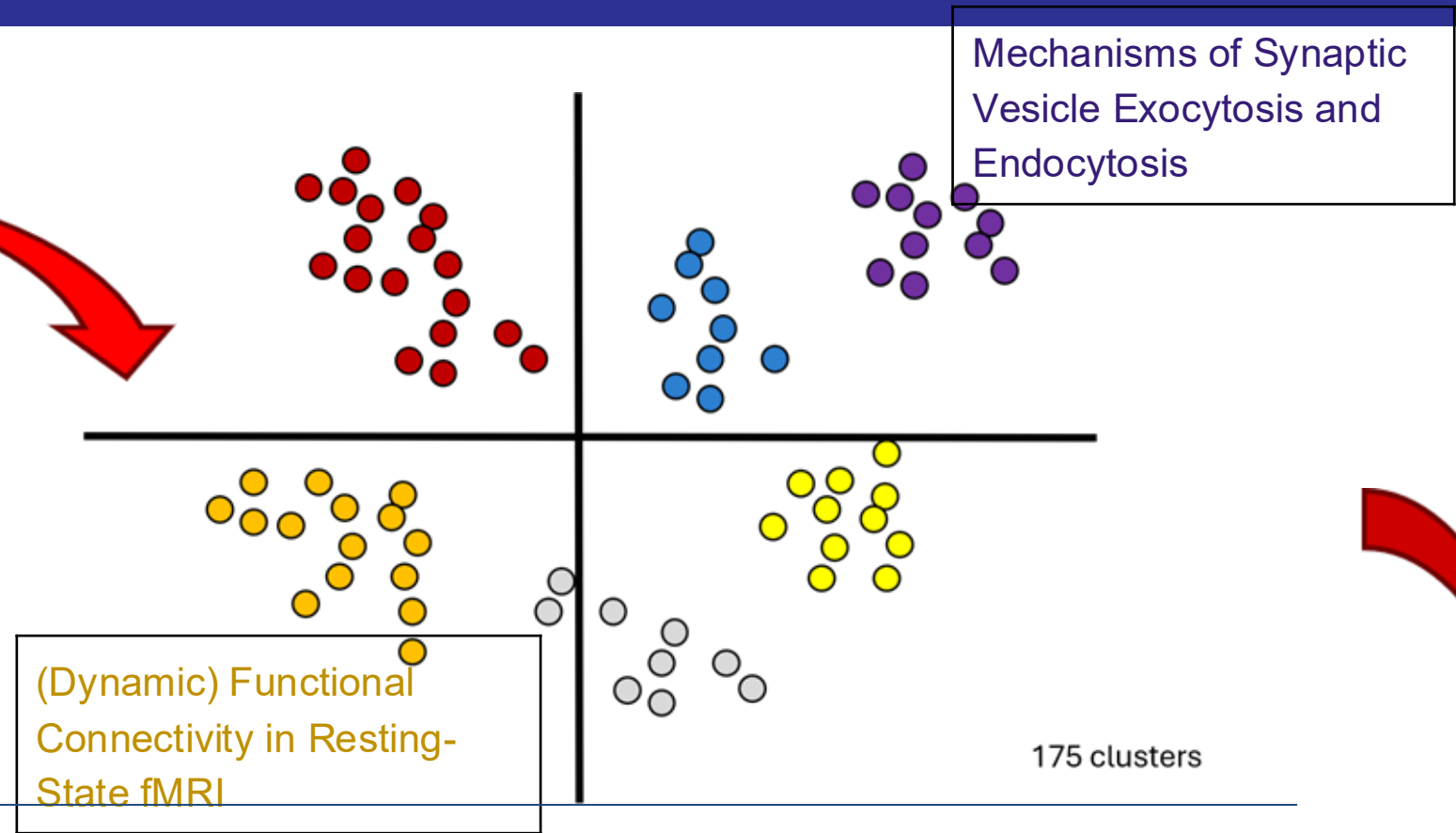


Senden (2026) *Aperture Neuro*

Abstract
Brain activity during rest displays connections comprising the human dynamics of this activity. Here, we report which fast neural dynamics in the from diffusion MRI t activity at the millise

Abstract
Numerous studies have used functional magnetic resonance imaging (fMRI) to characterize functional connectivity between cortical regions by analyzing correlations in blood oxygenation level dependent (BOLD) signals in a resting state. However, to date, there have been only a handful of studies reporting resting state BOLD signals in white matter. Nonetheless, a growing number of reports has

Abstract
Central amygdala neurons expressing protein kinase C-delta (CeA-PKCδ) are sensitized following nerve injury and promote pain-related responses in mice. The neural circuits underlying modulation of pain-related behaviors by CeA-PKCδ neurons, however, remain unknown. In this study, we identified a neural circuit that originates in CeA-PKCδ neurons and terminates in the ventral region of the zona incerta (ZI), a subthalamic structure previously linked to pain processing. Behavioral experiments show that chemogenetic inhibition of GABAergic ZI neurons induced bilateral hypersensitivity in uninjured mice and contralateral hypersensitivity after nerve injury. In contrast, chemogenetic activation of GABAergic ZI neurons reversed nerve injury-induced hypersensitivity. Optogenetic manipulations of CeA-PKCδ axonal terminals in the ZI further showed that inhibition of this pathway reduces nerve injury-induced hypersensitivity whereas activation of the pathway produces hypersensitivity in the uninjured paws. Altogether, our results identify a novel nociceptive inhibitory efferent pathway from CeA-PKCδ neurons to the ZI that bidirectionally modulates pain-related behaviors in mice.

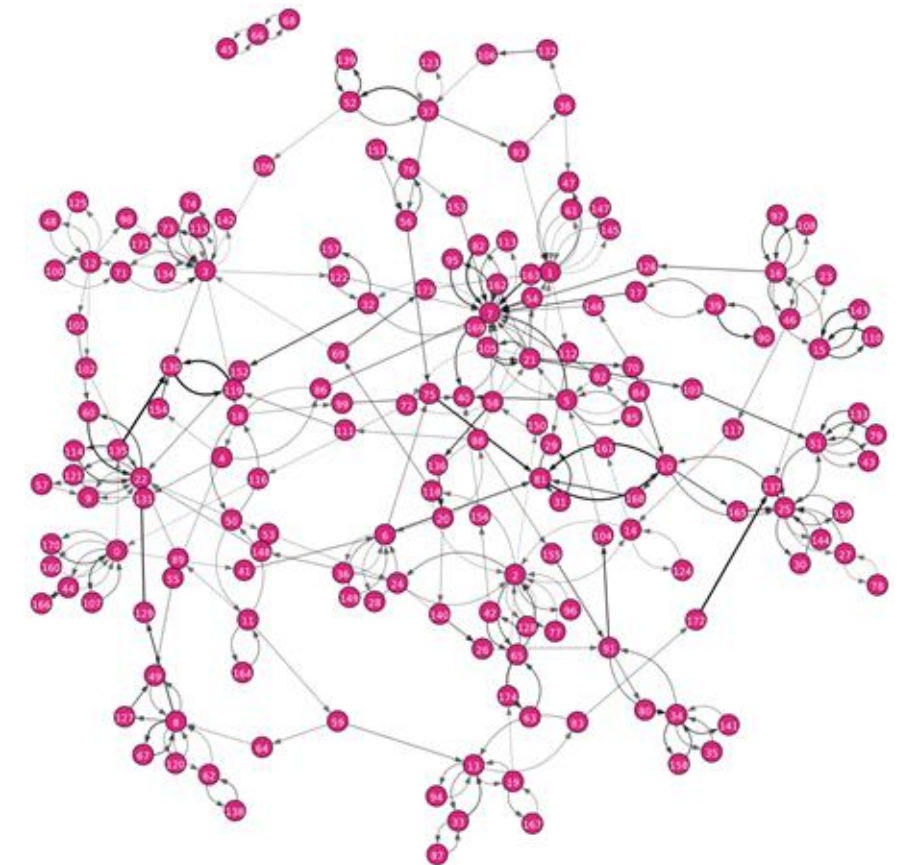


Quantitative trend analysis

Current Challenges

- Integrating Across Scales
- Understanding the Neuro-Immune Axis
- Mapping the Biology of Individual Differences
- Cracking the Code that Links Circuits To Behavior
- Turning Mechanistic Insights into Durable Therapies

Qualitative trend analysis

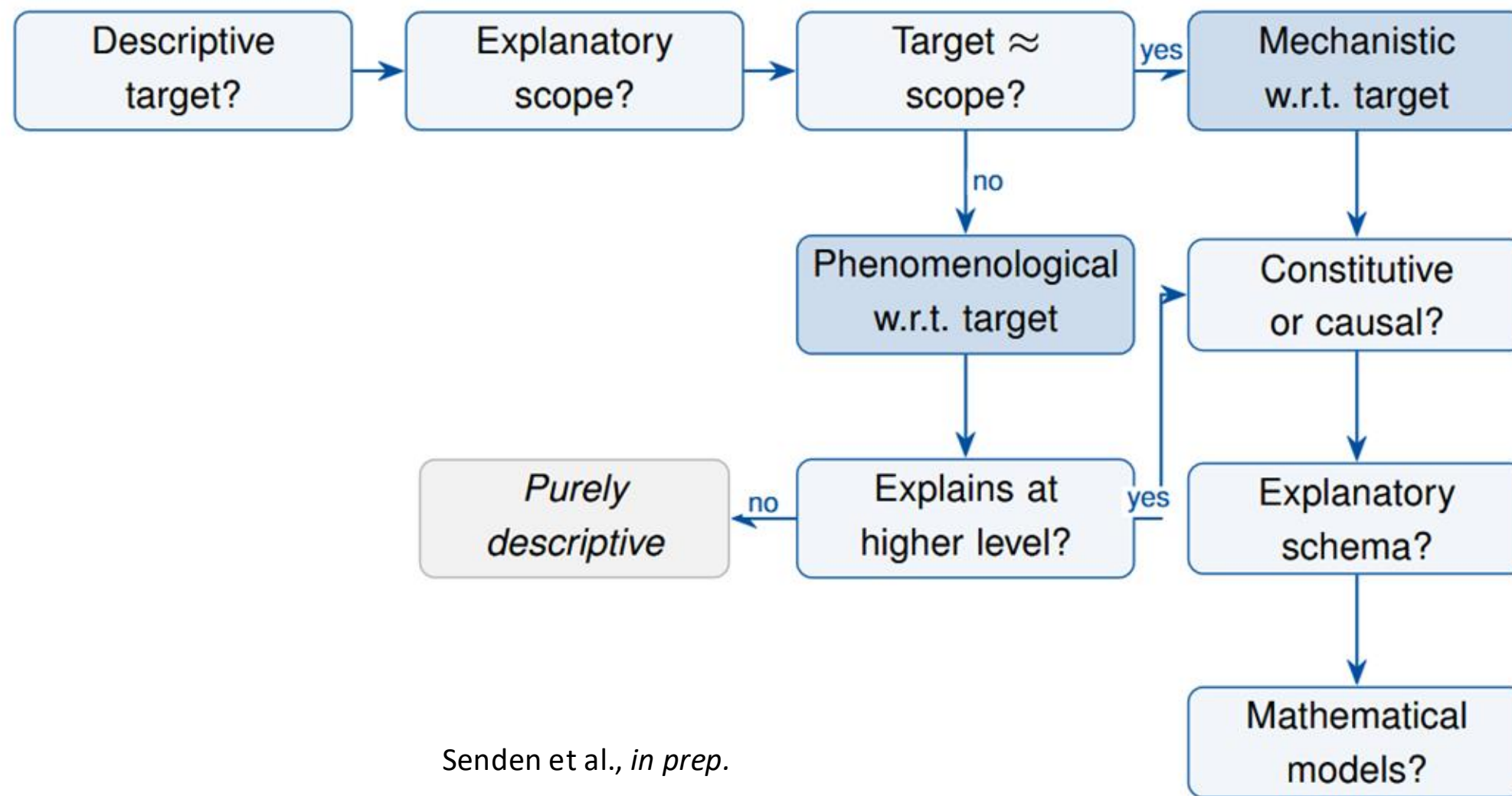


Cluster interactions



A Conceptual Toolkit For Theory

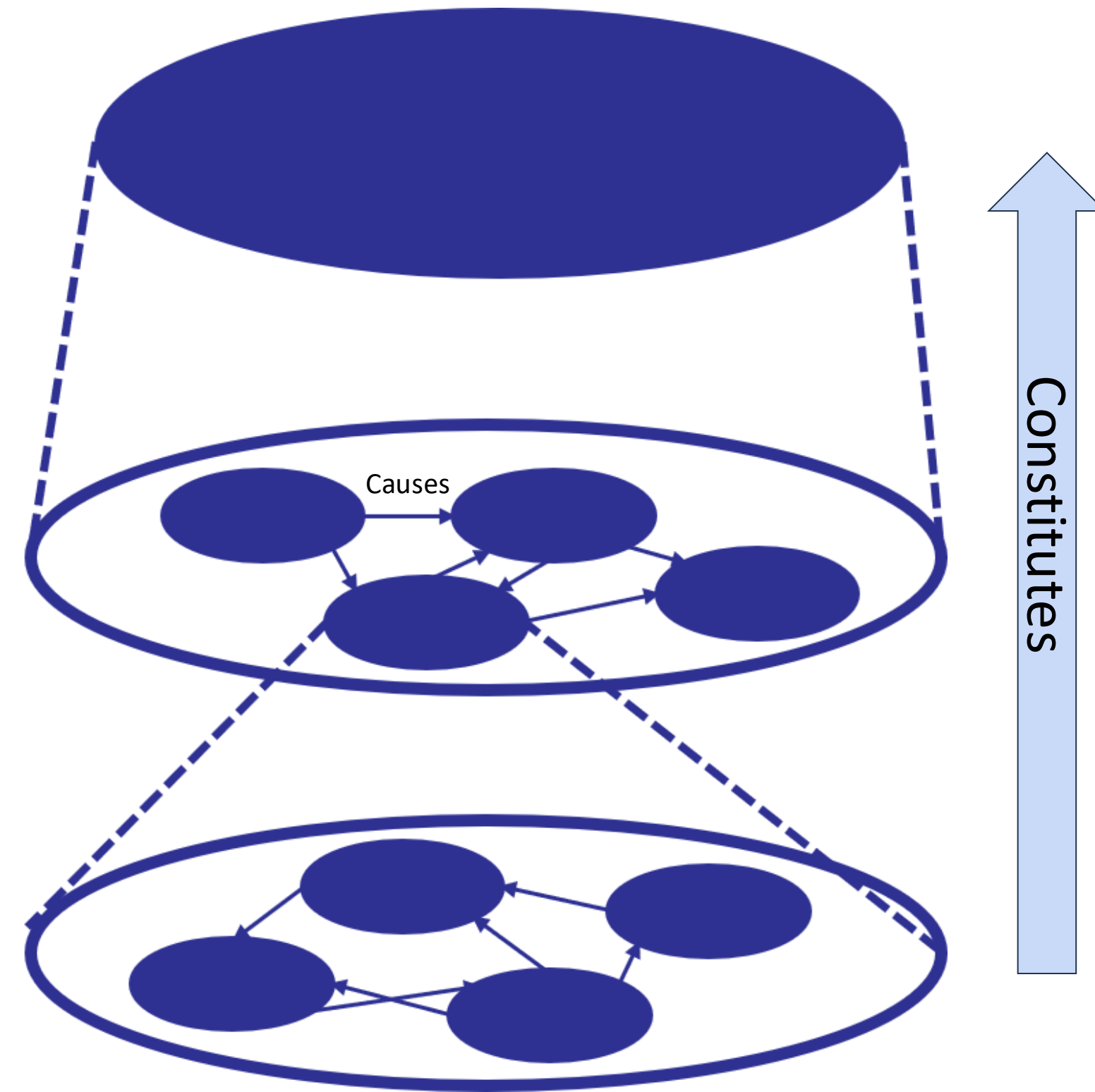
Thinking about theories



Senden et al., *in prep.*

Hierarchical Web of Phenomena

Each both *explanandum* and *explanans*



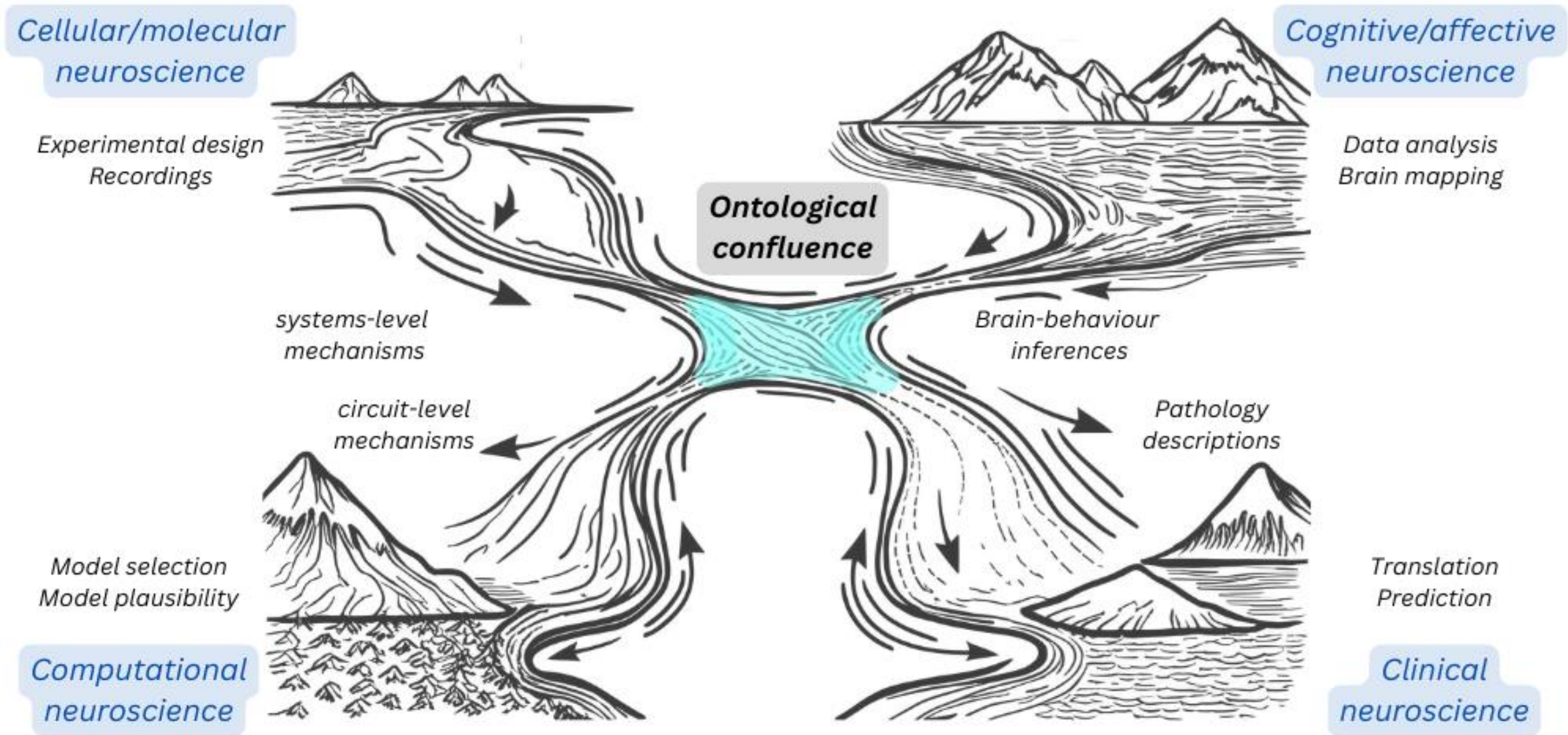
G. Baracchini, E. Muller, J. Shine, “Bridging the epistemological divide in neuroscience to improve ontological clarity” Aperture Neuro, 5: SI 1, 2025
<https://doi.org/10.52294/001c.138841>



Giulia Baracchini, Ph.D.

**Post doc with Mac Shine
University of Sydney**

Ontological-Epistemological clash



Baracchini, Müller, Shine (2025) *Aperture Neuro*

Mapping out the neuroscientific landscape

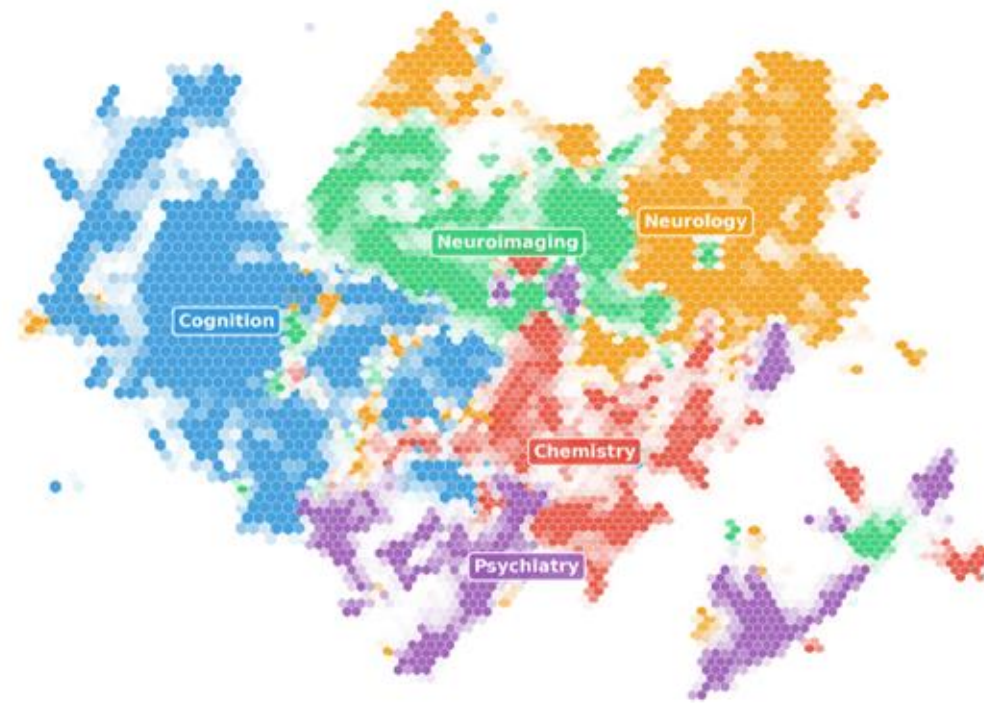
work building on Senden (2026) *Aperture Neuro*

in collaboration with Prof. Mac Shine and Sean Simunovic (USyd)

1. Visualising 64D space in 2D via UMAP:
175 clusters identified

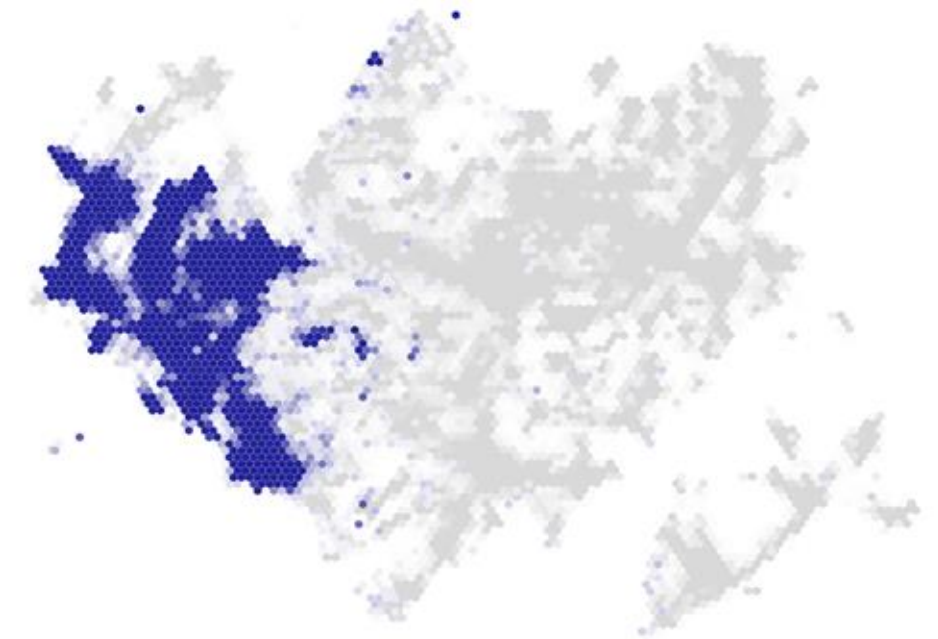


2. Merging clusters into 5 main territories



3. Situating research question within this mapped out neuroscientific landscape

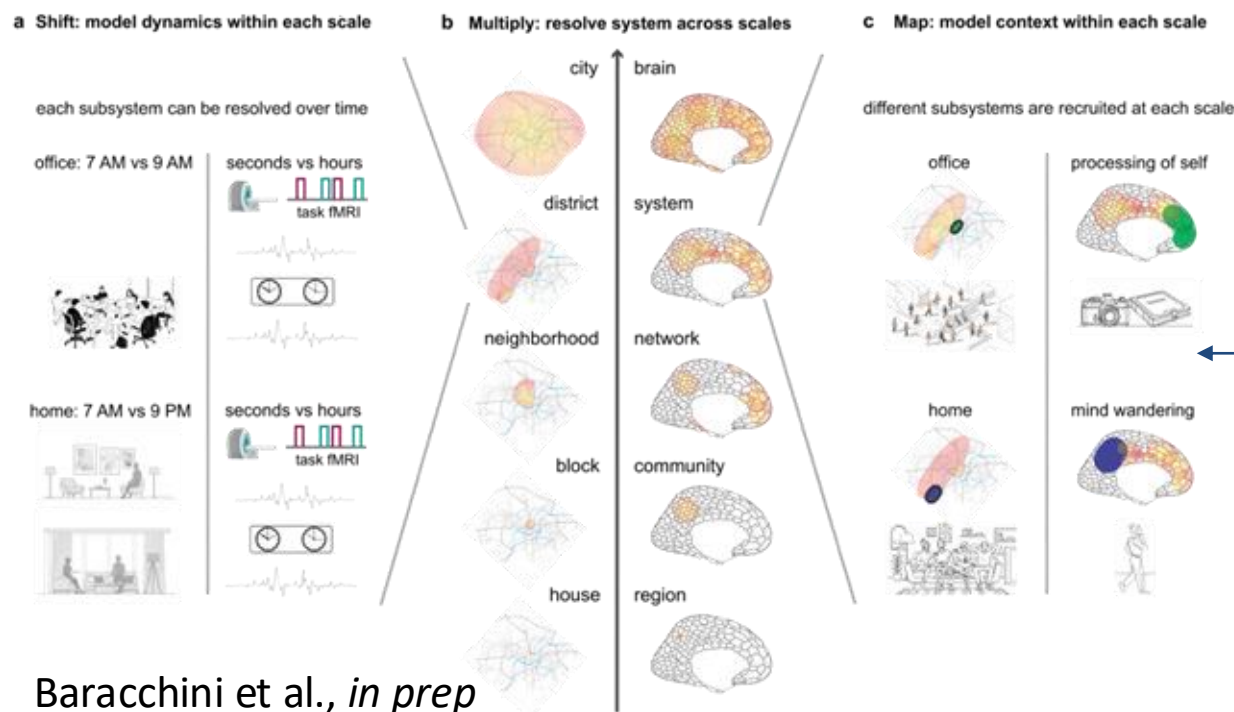
Human cognition (n=49,278/461,316)



Animal cognition (n=33,428/461,316)



urban architecture; statistical physics (dynamical systems); neuroimaging



4. Gaining a new vantage point that lets us ask more integrated questions. As OHBMers, mapping is what we love doing! But is a map sufficient to reach ontological clarity?

5. We have been unable to reach ontological clarity using semantics alone (e.g., psychology-attention), time to draw on other complex systems disciplines?

V. Calhoun. “Data-guided neuroimaging and visualization: from functional decomposition to dynamic fusion.” Aperture Neuro, 5: SI 1, 2025
<https://doi.org/10.52294/001c.140427>



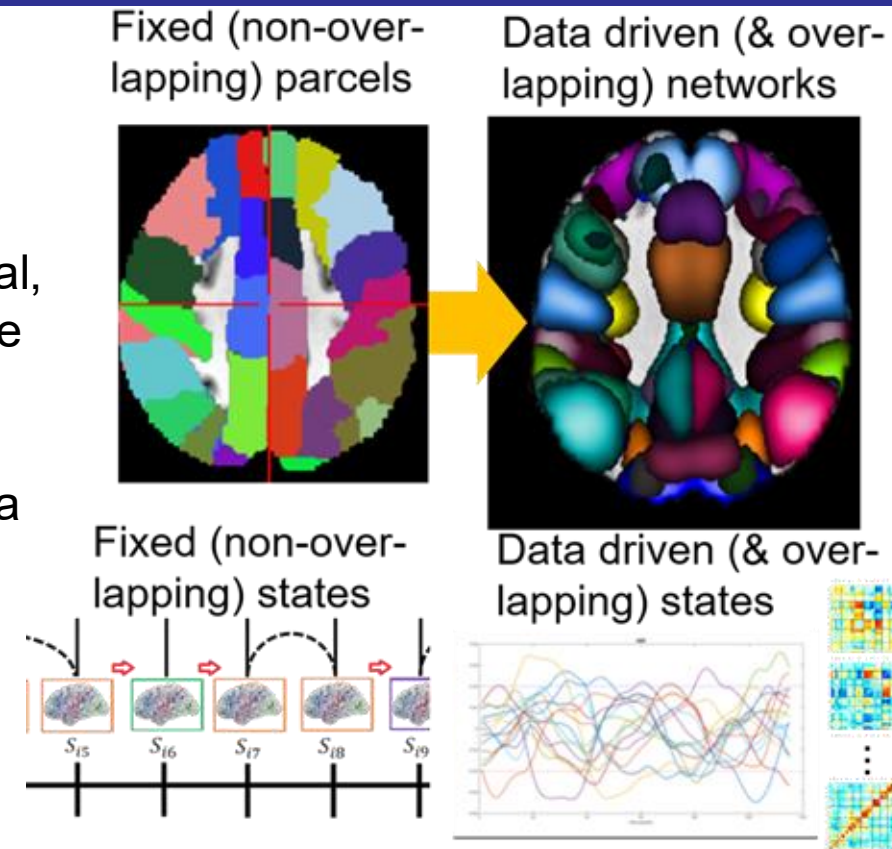
Vince Calhoun, Ph.D.

**Founding Director of the
Center for Translational
Research in Neuroimaging
and Data Science
(TReNDS) at Georgia State
University, Emory
University and Georgia
Institute of Technology**

Bringing It Together Without Losing the Biology

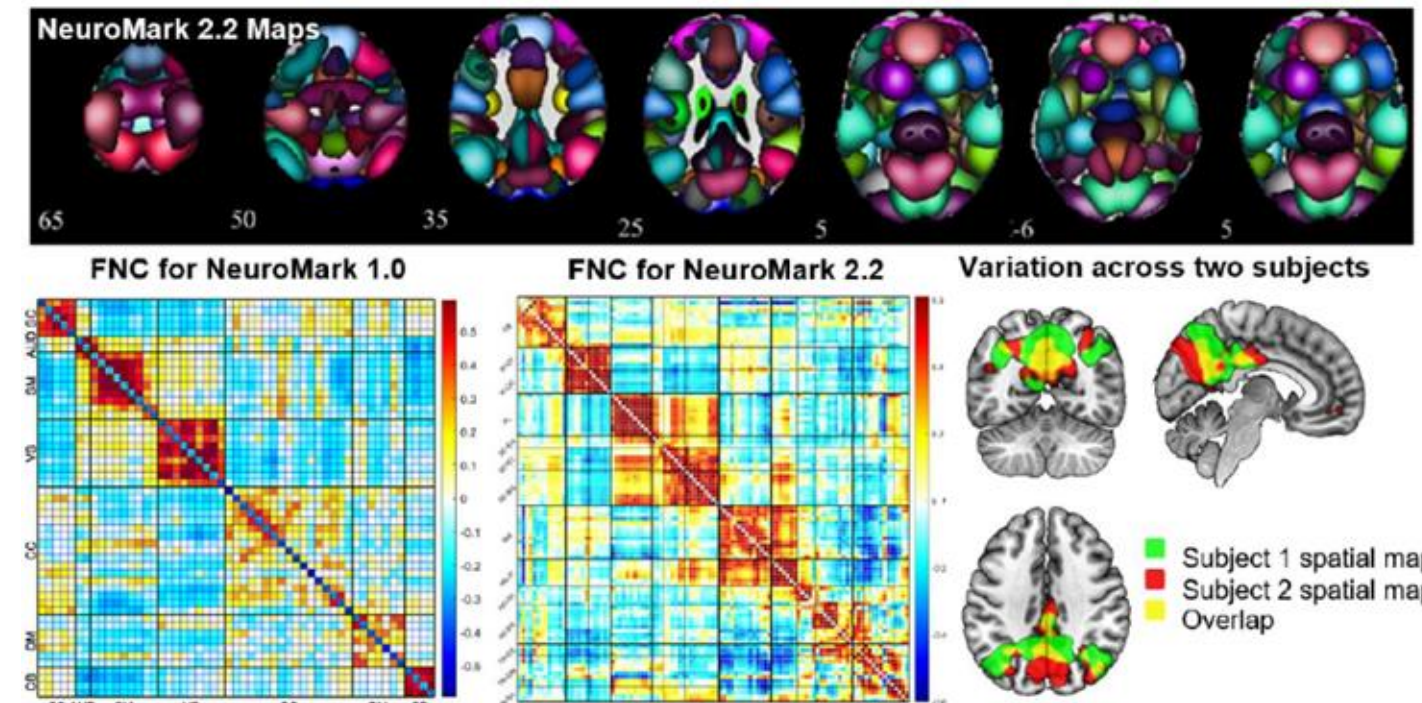
Stay close to the data:

- Use the data to discover structure rather than forcing early low-dimensional summaries.
- Brain data are intrinsically high-dimensional, overlapping, and spatiotemporal. Premature simplification can erase biologically meaningful variation.
- Hybrid models (e.g., NeuroMark) can find a balance between fully data driven (hard to compare across studies and subjects) and prespecified/binary ROIs
- Data-driven structure can reveal patterns before theory catches up



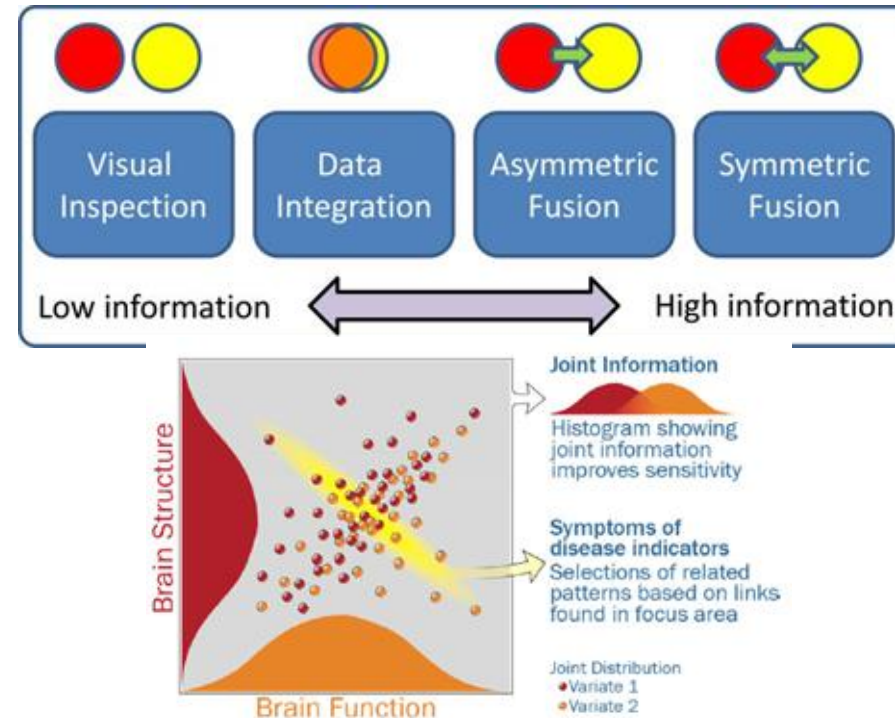
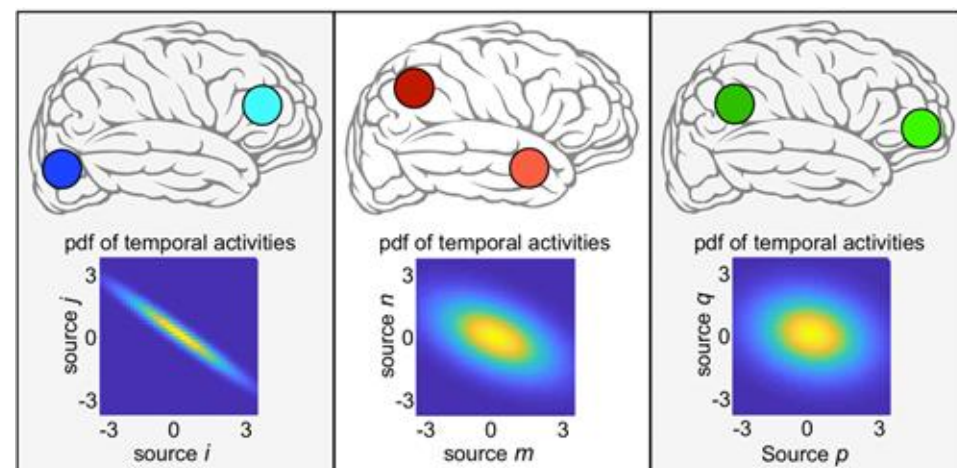
Goldilocks reduction

We need compact, interpretable intermediate representations – not raw complexity, but not oversimplified summaries either. Hybrid approaches such as NeuroMark preserve both correspondence and individual variation, also avoiding data leakage..

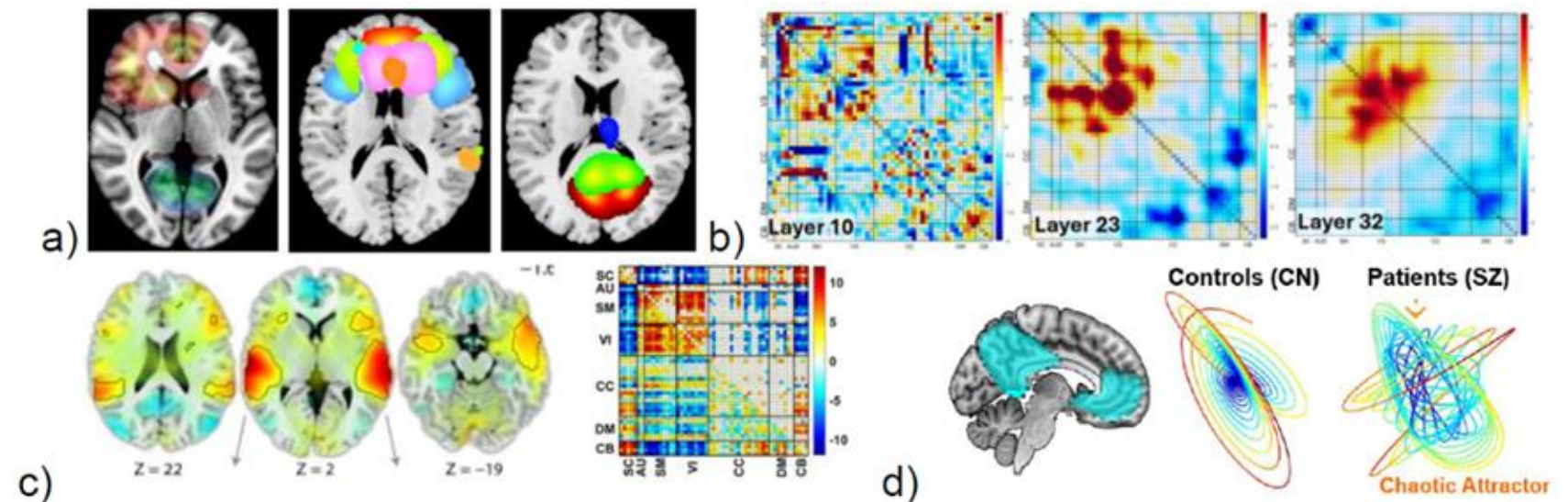


Integration through dynamics and fusion: The brain is spatiotemporal and multimodal. Meaningful integration requires models that capture evolving states and structured links across modalities, not just larger static feature sets.

Temporal dynamic Spatial dynamic Spatiotemporal dynamic



‘Expressive’ visualization as scientific scaffolding: As models become more complex, visualization becomes more important. The goal is to expose spatial, temporal, and latent structure so models support discovery, not just prediction.



V. D. Calhoun, "Data-guided neuroimaging and visualization: From functional decomposition to dynamic fusion," *Aperture Neuro*, vol. 5, 2025, *PMC Journal - in process*.

A. Iraj, A. Faghiri, N. Lewis, Z. Fu, S. Rachakonda, and V. D. Calhoun, "Tools of the trade: Estimating time-varying connectivity patterns from fMRI data," *Soc Cogn Affect Neurosci*, 2021

J. Sui, D. Zhi, and V. D. Calhoun, "Data-driven multimodal fusion: Approaches and applications in psychiatric research," *Psychoradiology*, vol. 3, p. kkad026, 2023.

Discussion Questions: Fusing Data and Relating Literature

The field is overwhelmed with **fragmented Research and Data** from different spatial and temporal scales as well as modalities. The literature is also overwhelming - too much to follow for even subspecialties. We need ways to curate, integrate, and draw insight and nuance from both.

- What are the best ways forward to integrate the research as well as to curate and relate the literature?
- What ideally would such infrastructures look like - in theory and in practice? What needs to change?
- Practically speaking, how might one efficiently glean data and literature relationships to establish mechanisms, models, insights, meaning, and understanding?
- Theoretical frameworks and cross scale mechanistic models are fundamental to this effort. How might their growth be catalyzed?
- Where and how do we start? What should be done now? How does it grow? Who decides how it grows? How can it be incentivized?
- What role with AI play in all this?
- What might be the ultimate benefits from this effort?...or the costs if we don't implement this?