NeuroTech
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Ann-Sophie Barwich (Indiana University, Bloomington)
"Imaging the living Brain: Reductionism revisited in times of dynamical systems"

Withstanding contemporary fashion in the philosophy of science, this paper outlines an argument in favor of reductionist explanations of sensory perception via molecular mechanisms in neurobiology. It explores in depth the recent application of new real-time molecular imaging techniques to mixture coding in olfaction. Seemingly emergent psychological expressions of odor, irreducible to the physical structure of the stimulus, are linked back to underlying molecular mechanisms at the receptor level. This paper explicates the necessity to rethink the reductionist conceptualizations of material causes in parallel with advances in experimental methodology.

Danielle Bassett (University of Pennsylvania) **[Keynote]**
"Perturbative approaches to probing brain network function"

The human brain is a complex organ characterized by heterogeneous patterns of interconnections. Non-invasive imaging techniques now allow for these patterns to be carefully and comprehensively mapped in individual humans, paving the way for a better understanding of how wiring supports our thought processes. While a large body of work now focuses on descriptive statistics to characterize these wiring patterns, a critical open question lies in how the organization of these networks constrains the potential repertoire of brain dynamics. In this talk, I will describe an approach for understanding how perturbations to brain dynamics propagate through complex wiring patterns, driving the brain into new states of activity. Drawing on a range of disciplinary tools – from graph theory to network control theory and optimization – I will identify control points in brain networks and characterize trajectories of brain activity states following perturbation to those points. Finally, I will describe how these computational tools and approaches can be used to better understand the brain's intrinsic control mechanisms and to inform stimulation devices to control abnormal brain dynamics, for example in patients with medically refractory epilepsy.

Dan Burnston (Tulane University)
"Complex Mapping Tools and Task Ontologies"

New analytical tools in neuroscience have been employed as aids for thinking about cognitive ontology. In particular, data-intensive meta-analytic tools are being developed to explore the relationship between psychological categories and brain activity. One strategy in this vein is to analyze the semantic groupings of psychological categories employed in fMRI studies using "topic models", and to see how these groupings correlate with patterns of brain activity (Poldrack & Yarkoni, 2016). Databases such as the Brain Atlas (Poldrack et al., 2011) catalog this information, with the hope that it will produce clarity regarding how psychological concepts relate to brain processes, and even produce revisions to our psychological ontology that better track brain mechanisms. I call these "complex mapping strategies" for doing cognitive and neural ontology. I will argue that these projects do not succeed at rescuing standard explanatory schemas in cognitive neuroscience and propose an alternative based on what I call "task ontology".

Carl Craver (Washington University) and **John Bickle** (Mississippi State University and University of Mississippi Medical Center) **[Keynote]**
"New Tools and Artifacts: The Evidential Selection Problem and a Solution in Practice"

One guiding desideratum in experimental practice is the avoidance of experiment artifacts. The introduction of new research tools makes this desideratum especially important. Building on a few isolated discussions in philosophy, and using several examples from the history of biological science, Craver offers an analysis of experimental artifacts and a taxonomy of artifacts which arise at different stages of experimental practice. Bickle then explains a strategy for integrating results from various distinct types of experiments to avoid experiment artifacts. He derives this approach directly from practices in a field, 'molecular and cellular cognition,' that was itself initially built upon and sustained by developments of an experiment tool new to neuroscience (gene targeting). Craver concludes by connecting our discussion of experiment artifacts with a broader sense of the term, artifacts as human creations, and the kinds of 'maker's knowledge' at work in the processes that bring them into existence.

Luis Favela (University of Central Florida)
"'It takes two to make a thing go right': The coevolution of technological and mathematical tools to explain scale-free neuronal activity"

Recently, it has been increasingly argued that experimental tools are not just important to neuroscience research but are fundamental. Put in its most extreme terms, the line of thought goes like this: from Golgi's staining technique to fMRI, the history of neuroscience is a history of tool development. Moreover, it has been argued that this history is best characterized as one that exhibits reductionist and mechanistic explanations. Across these claims, little to no mention of data analysis methods are mentioned nor the underlying assumptions of said methods. Here, I argue that the mathematical assumptions of applied data analyses have played critical roles in the history of neuroscience. Such assumptions have resulted in blind spots of key features of target phenomena. First, I present the Hodgkin and Huxley model of action potentials as an example of research constrained by technological and mathematical limitations of the time. Second, I draw attention to a feature of neurons that is overlooked by the Hodgkin-Huxley model: scale-free dynamics. After describing scale-free dynamics, I then point out a consequence scale-free neuronal dynamics has for mechanistic explanations of neuronal activity. I conclude by discussing the necessity of mathematical developments in providing appropriate accounts of scale-free neuronal activity.

Philipp Haueis (Bielefeld University)
"Exploratory concept formation and tool development in neuroscience: the case of "bug detectors" and the "default mode" of brain function"

In this paper, I argue that tool development and concept formation go hand in hand in exploratory experiments in neuroscience. In exploratory experiments, researchers do not test hypotheses derived from theories of the system, but instead form novel concepts which describe neural entities or activities in terms of the experimental conditions under which they are investigated. If setting up the experimental conditions requires novel instruments or analysis techniques, then conceptual and tool development are part of the same experimental process. I argue that the exploratory formation of the concepts "bug detector" and "default mode" fulfil this conditional. These cases also illustrate two normative principles for evaluating the descriptive adequacy and epistemic fruitfulness of novel concepts. Tools play a crucial role for following these principles, which further tightens the link between concept formation and tool development in exploratory experiments.

Gregory Johnson (Mississippi State University)
"Hacking, Microscopes, and Calcium Imaging"

Hacking's analysis of light microscopy provides a "modest" argument for scientific realism (1983). We do see through a microscope and we are "convinced about the structures that we see" because we can see the same features of a specimen with different kinds of microscopes, we are able to actively engage with the specimen, and we have a sufficient understanding of the theory underlying the microscope and of at least some of the biological and chemical properties of the specimen.

Separate from Hacking's worries about realism is a question about the verification of proposed explanations for cognitive processes. Typically, investigations in cognitive psychology are indirect: after observing behavior, we make inferences about internal components and activities. In contrast, investigating the relevant neurobiology provides a more direct method of investigation. What "more direct" means is complicated, but, as I show, Hacking's criteria are satisfied by a technique such as calcium imaging. Hence, by Hacking's standards, calcium imaging lets us "see" neurobiological processes. Since observing a process is clearly superior to an indirect method of detecting it, we should prefer at least some neurobiological investigations over those that are typically used in cognitive psychology.

Josef Kay (University of California, Irvine)
"Integrated Explanations in Psychedelic Neuroscience"

Psychedelics are attracting renewed scientific interest, in part due to their clinical potential as transdiagnostic therapeutic agents capable of facilitating rapid and enduring benefits. Psychedelic neuroimaging is an emerging research program that combines pharmacological intervention, neuroimaging, and computational tools in order to measure and model induced changes in activity and functional connectivity in brain networks. Using conceptual resources from mechanistic accounts of discovery and explanation, I articulate the goal of psychedelic neuroimaging as contributing to a multilevel explanation of the characteristic subjective and therapeutic effects of psychedelics. Results from psychedelic neuroimaging form new explanatory targets to be explained by receptor-mediated effects.

In turn, neuroimaging results provide new resources for explaining commonly-reported experiences such as “ego-dissolution” and their relevance in mediating therapeutic outcomes. Ultimately, psychedelic neuroscience provides an exemplar case study of how tools for intervention, measurement, and modeling can be combined in order to generate integrated explanations in neuroscience.

Chia-Hua Lin (University of Virginia)
“Developing Techniques as Generating New Know-how: A Case Study of the Chomksy Hierarchy”

Mathematical constructs developed to advance knowledge in one discipline are sometimes applied to study a different subject in another discipline. Philosophers of science have been analyzing the cross-disciplinary use of mathematical constructs in terms of knowledge transfer. While the term “transfer” suggests a conservative process in nature, various case studies suggest that modifying the body of knowledge is indispensable to a satisfactory cross-disciplinary transfer. This paper discusses the tension between the conservation and adaptation aspects in the cross-disciplinary transfer of mathematical constructs and their associated knowledge. I argue that to begin resolving this tension, one may distinguish different kinds of knowledge, such as mathematical knowledge, knowledge about the empirical world, and knowledge of techniques (“know-how”). The tension can then be resolved by noting that generating knowledge of one kind and conserving knowledge of another kind may just be two sides of the same coin. I illustrate by examining formal language theory, especially the Chomsky hierarchy, as it is used in linguistics, software engineering, and experimental psychology.

Astrid Prinz (Emory University) **[Keynote]**
“Hybrid brains: Interfacing living neurons and circuits with computational models”

Computational modeling of neurons and circuits is a growing component of neuroscience research and can fruitfully complement experimental investigations, ideally in a mutually informative feedback loop between experiments and modeling studies.

The dynamic clamp technique allows for an even more direct interaction between experimentation and modeling by interfacing living neurons and circuits with computational models in real-time and at multiple levels, ranging from models of cellular components and synapses to models of individual neurons or entire circuits. The dynamic clamp thus creates hybrid in vivo – in silico systems in which living brains and computer models directly “talk to each other”. This takes advantage of both worlds, combining the ground truth of experimental investigation of living neural systems with the complete control over neural, synaptic, and circuit parameters provided by computational models.

I will explain how the dynamic clamp operates, will describe various dynamic clamp applications, and will give examples of dynamic clamp studies that have furthered our understanding of circuit operation. I will also discuss caveats of the technique, including technical issues and limitations, and the inherently embedded question what we can learn from computational models and hybrid systems, and to what extent they can be “trusted”.

Sarah Robins (University of Kansas) **[Keynote]**
"The Silent Engram"

Recently, Josselyn, Köhler, and Frankland claimed that "not only can contemporary rodent studies claim to have found the engram, but also have identified means to control it" (*Nature Reviews Neuroscience,* 2015: 531). Their optimism comes largely from the progress brought on by the use of optogenetics to identify and intervene in memories at the neurobiological level. In this paper, I explore the work Tonegawa and colleagues have done using optogenetic techniques to explore the features of the engram and the nature of memory more generally. A centerpiece of their recent work involves positing *silent engrams*: engrams in a state where they cannot be activated by standard retrieval processes, but *only* by optogenetic methods. Silent engrams are invoked to explain a range of memory phenomena, but they are curious entities. Are they engrams? Calling them such conflicts with the definition of the engram that has guided neurobiology for decades. What's more, the definition of silent engrams appeals to the method used to identify them (i.e., optogenetics), which could suggest they are a mere artifact of this tool.

Lauren Ross (University of California, Irvine)
"Tracer technology in neuroscience: Causation, constraints, and connectivity"

This paper examines tracer and tagging techniques in neuroscience, which are used to identify neural connections in the brain and nervous system. These connections capture a type of "structural connectivity" that is expected to inform our understanding of the functional nature of the brain (Sporns 2007). This is due to the fact that neural connectivity constrains the flow of signal propagation, which is a type of causal process in these tissues. This work explores how tracers are used to identify causal information, what type of causal information they provide, and how they contribute to the literature on mark transmission and mechanistic accounts of causal explanation.