Information & the Cognitive Sciences Workshop

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האוניברסיטה העברית בירושלים
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A. Scarantino: Probabilistic Information: A Brief History and a New Theory

Ever since Dretske (1981) published his seminal Knowledge and the Flow of Information, philosophers have tried to develop an adequate theory of information. The Holy Grail of this research program is to make sense of information as a naturalistic commodity, and then use it to provide a reductive account of knowledge and other sophisticated mental capacities. Attempts to naturalize information have used three main tools: laws, counterfactuals and probabilities. I will argue that probabilistic theories are the most promising of the lot, and trace a brief history of attempts to use probability to provide a naturalistic theory of information. I will then offer a new probabilistic theory, according to which signals carry natural information by virtue of changing the objective probabilities of various states of affairs, relative to background data. The Probabilistic Difference Maker Theory (PDMT) of natural information I introduce includes both a qualitative account of information transmission and a measure of natural information in keeping with the basic principles of Shannon's communication theory and Bayesian confirmation theory. It also includes a new account of the informational content of a signal, understood as the combination of the incremental and overall support that the signal provides for all states of affairs at the source. Finally, I compare and contrast PDMT with other probabilistic and non-probabilistic theories of natural information, most notably Millikan's (2013) recent theory of natural information as nonaccidental pattern repetition.

M. Usher: From Mutual Information and Bayesian decision models to Mental Representations (and Misrepresentation)

Since Dretske (1981) natural-information was suggested to ground a theory for the content of mental representations. An important challenge of such a theory is to account for the content of both veridical and non-veridical mental representations, i.e., for misrepresentations, which pose a challenge to causal theories of content. Here I will build on the Probabilistic Difference Maker Theory (Scarantino 2015) to use Mutual-Information between mental-brain representational states of an organism that discriminates objects in its environment and the corresponding objects (Usher, 2001). Using this tool, I will first characterise conditions for the causal relations between objects and the repertoire of mental representations, for the latter to represent the former. When these conditions are satisfied we can determine the content of a mental representation as the object that is mostly likely to have tokened the mental representation in a probabilistic process of perceptual categorization. Second, I will examine a Bayesian algorithm that allows neural systems to make use of stochastic samples of signals generated by the objects to select representations that satisfy mutual-information conditions, and also to trigger optimal decisions that reflect environmental biases and contingencies. Finally, I will show that this theory can deal with problems of decision/frequency bias that has been raised against statistical theories of content (Millikan 1989).

E. Ahissar: Perception as an organism-environment closed-loop process

Empirical data collected from a variety of mammalian perceiving systems suggest that (i) perception is an active process and (ii) a perceiving system interacts with its environment via motor-sensory-motor (MSM) closed loops. We hypothesize that these MSM-loops converge to steady-states ('attractors') that represent the relevant 'percepts'. We further hypothesize that individual loops perceive individual features and that objects are perceived by a collection of loops. With this scheme, an external feature is continuously represented by the loop's state, and the reliability of this representation is a function of the distance of the current loop's state from its steady-state. What distinguishes this model from an attractor neural network model is that the converging network is the entire MSM-loop, including the external feature, and thus the representation of the feature is never "internal" - as long as the MSM-loop interacts with the external feature, that feature is part of the loop.

N. Fresco & E. Jablonka: Functional Information and Selection in Learning and Communication

Competing theories of information have been applied across a wide range of domains. We offer a new account of functional information that is pertinent to cognition. After rejecting some problematic assumptions about information, we offer a taxonomy that is based on an underlying principle of exploration-stabilization in ontogenetic learning. We distinguish between D-selection (Darwinian selection: selecting among multiplying replicating entities) and S-selection (Sample selection: selecting, without replication and multiplication, a subset from a set according to some value criterion) and argue that the Price equation can be applied to S-selection. We also submit that functional information is the superclass of semantic-symbolic information whose meaning and veracity crucially depend on the symbolic context.

O. Shriki: How Sensory Deprivation and High Plasticity may lead to Hallucinations and Synaesthesia: An information theoretic perspective

Recurrent connections are abundant in cortical circuitry but their functional role has been the subject of intense debates. The talk will present an information-theoretic approach to investigate the role of recurrent connections in the context of sensory processing. Specifically, I will describe a neural network model in which the recurrent connections evolve according to concrete learning rules that optimize the information representation of the network. Interestingly, these networks tend to operate near a "critical" point in their dynamics, namely close to a phase of "hallucinations", in which non-trivial spontaneous patterns of activity evolve even without structured input. Various scenarios, such as attenuation of the external inputs or increased plasticity, can lead the network to cross the border into the hallucinatory phase. The theory will be illustrated through applications to a model of a visual hypercolumn, a model of tinnitus and a model of synaesthesia.

N. Tishby: Predictive Information and the Emergence of Cognitive Hierarchies

Arguably, the primary condition for life in general and cognition in particular is the ability to efficiently extract information from past observations that is relevant for valuable future behavior. Taking this a single first principle, we can quantitatively describe the subjective perception of time and the emergence of cognitive hierarchies in sensation, learning, and planning. We formulate a general computational paradigm: minimization of predictive information subject to future value and metabolic costs constraints, and show how it can be applied to model various neuroscience and cognitive tasks. In particular, I will discuss applications to auditory perception, motor control, music, and the large scale structure of human language.

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