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Comment

Towards a unification of evolutionary dynamics
Comment on "Answering Schrödinger's question: A free-energy formulation" by Maxwell James Désormeau Ramstead et al.

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In 2006 Karl Friston introduced the free energy principle (FEP) to neuroscience as a unifying concept [1]. This proposal, along with its use in developing the 'Bayesian Brain' formulation quickly gained traction and a 2008 feature article in New Scientist heralded it as providing a promising unified theory of the brain [2]:

Dr. Friston has recently been rated the most influential neuroscientist of the modern era [3], which may be due to his compelling interpretation of much of existing neuroscience within the FEP paradigm.

Schrödinger made significant progress in answering his own question by speculating that life's internal model might exist in a digital form, perhaps coded with aperiodic crystals. Clearly, Schrödinger expected that understanding life's internal model would be key to answering his question. However, in this article, genetics is little discussed, and no connection is made to its fundamental role in life [4]. Instead the thrust of the argument describes life in terms of Markov blankets. Friston has previously noted the central importance but unanswered nature of the biological relationship between Markov blankets and genetics [5].

The authors suggest a heuristic methodology called variational neuroethology, to integrate the free energy principle with Tinbergen's four levels of behavioral analysis: ontogeny, phylogeny, adaptation and mechanism.

The central insight of the FEP is that systems act, in an evidence-based Bayesian manner, to reduce the prediction error of their internal models which describe autopoietic strategies for existence within the external world. This may be expressed using Tinbergen's categories. Systems may reduce prediction error in two ways: by evolving more accurate internal models over evolutionary time (phylogeny) or causing their interactions with the external world to more closely conform to the predictions of their current models (active inference or ontogeny). Ontogeny instantiates adaptations through mechanisms coded by the internal model which function to provide greater fitness or selective advantage. In turn, the evidence of adaptive success or failure updates the existing internal models. The FEP also has the advantage of providing a mathematically tractable description of system dynamics [1].

Much of known neuroscience may be straightforwardly interpreted in terms of this principle [1], leading to its widespread adoption within the community. Under Friston's leadership the free energy paradigm has been further developed and extended to encompass biology [5] and now, with this article, the social sciences.

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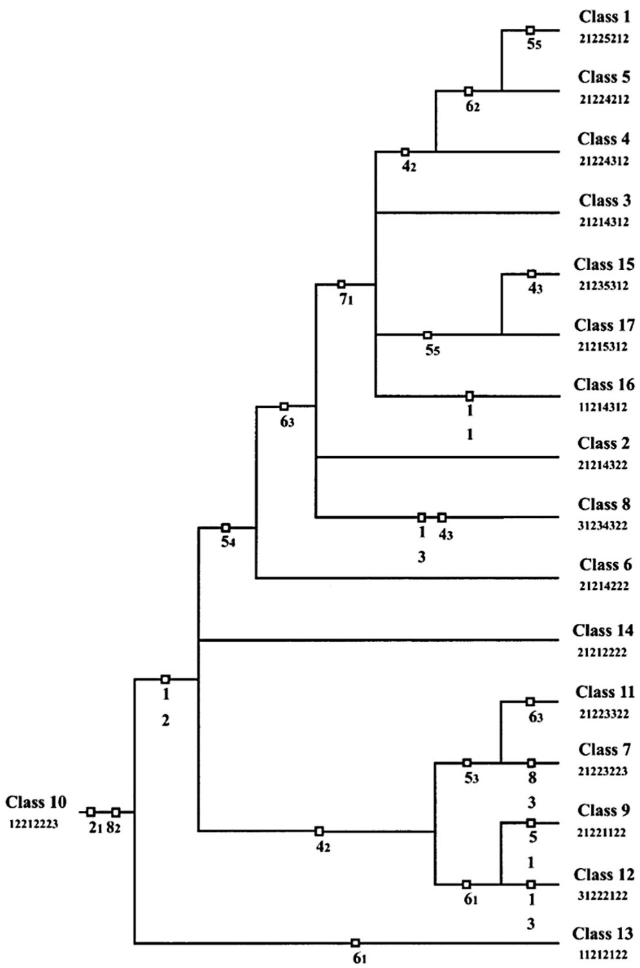

Fig. 1. A phylogenetic tree of 17 south-western US projectile point classes.

The Tinbergian levels are described as existing on a continuum of spatial/temporal scales and it is argued that a nested hierarchy of natural systems exist along this continuum, each separated from the others by a Markov blanket.

The crux of their argument 'is that organisms can be described in terms of a phase space induced by hierarchically nested Markov blankets'. Friston previously demonstrated that Markov blankets arise naturally to delineate ergodic systems and that crucially, within a short period of time, internal states of the system will tend to model external states [5]. Markov blankets resonate well with the FEP, as the FEP is formulated in terms of the internal and external and relies upon sensory and active states.

The most explicit example of a biologically nested hierarchy discussed is: sub-cellular bodies, cells, organs and organisms with their attendant physical boundaries forming Markov blankets: membranes, cell walls and epithelia. Perhaps Markov blankets might be better understood as informational boundaries rather than physical. Physical biological boundaries are constructed through the process of ontogeny. These structures are specified in the organism's internal genome, subject to its particular set of environmental circumstances. The boundaries between structures reflect a nested hierarchy of genetic knowledge, with subcellular bodies emanating from a small subset of this knowledge and successively wider subsets of this knowledge used to code for more inclusive structures: cells, organs and organism.

Genetics induce Markov blankets via ontogeny. If there is circular causality and Markov blankets, in turn, have induced life's internal models, life's genetics, this must have taken place over evolutionary time via phylogeny as might be consistent with models of abiogenesis such as the 'deep sea vent' or 'lipid world' hypotheses where boundaries are understood to have preceded genetics in life's history [6]. This argument might hint at a deeper relationship between phylogeny and ontogeny fully in tune with the FEP/Tinbergian paradigm: phylogeny gradually assembles an internal genetic model having the autopoietic knowledge required for existence and ontology instantiates this knowledge in physical mechanistic forms (phenotypes) which serve as an experimental test of the internal model. Those variations in mechanism which work (adaptations) form the evidence which updates the phylogenetic internal model.

A similar direct interpretation, in terms of an integrated FEP/Tinbergian paradigm, might be made of neural-based behavior and culture. Neural-based behavior emanates from internal mental models which evolve and are expressed (ontogeny) in behaviors. Those behaviors which contribute to the organism's fitness (adaptation) are retained and thus update, in a Bayesian manner, the underlying mental models (phylogeny). Behavioral adaptations function to provide a computational network (mechanism) linking the organism's sensory repertoire to its repertoire of actions and behaviors.

Cultural practices, for example arrowhead design, are often studied using phylogenetic methodologies adopted from evolutionary biology [7]; clearly many variations are experimented with and evidence-based knowledge of successes is retained within the body of cultural models (see Fig. 1). This process produces a family-tree history (phylogeny) of designs, designs used to construct (ontogeny) actual artifacts (adaptations) and the functional knowledge of artifacts which work (mechanism) is retained. In turn, successful adaptations and their variants serve as the raw material for the next generation of evolutionary cultural design. Thus, in accord with the FEP, internal cultural models evolve greater accuracy in their prediction of cultural fitness.

The 2003 paper cited above is titled: Resolving Phylogeny: Evolutionary Archaeology's Fundamental Issue, which may indicate that the social sciences have long been attempting a direct interpretation within the Tinbergian paradigm. While evolutionary archeology may focus on phylogeny and evolutionary psychology on adaptation [8], the FEP/Tinbergian paradigm may offer various fields in the social sciences a powerful and unifying interpretation, one which, as the authors note, may provide computationally tractable methods for modelling these evolutionary phenomena.

Undoubtedly, the FEP has great explanatory power and potential. As noted in this article, I have previously discussed its applicability to quantum theory as well as biology, neuroscience and the social sciences [9,10]. I expect that its rapid development will result in direct, almost obvious (in hindsight), unified interpretations of already well-established fields of scientific knowledge. This unified paradigm may serve as an accessible scientific description of our universe for a wide audience.

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