Co-constructing Markov blankets: tricky solutions

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Comment on Raja, V., Valluri, D., Baggs, E., Chemero, A., & Anderson, M. L. (2021) The Markov blanket trick: On the scope of the free energy principle and active inference. *Physics of Life Reviews*

In their important contribution to the free energy principle (FEP) literature, Raja et al. (2021) point out crucial shortcomings and issues for the FEP to meet its ambitious goals, including the provision of a unified science with specific focus on cognitive and biological sciences. Additionally, Raja et al. criticise an FEP ambition to establish an operationally defined, objective metaphysics or ontology through the FEP. We want to comment on these two critiques, and explore potential ways forward.

We shall first discuss the issues with the FEP ontology, as they also have implications for the promise of a unified science. The process of establishing a Markov blanket is fundamentally *co-constructed* by the modeller, their history, sociomaterial environment and research interests, and the real-world system in context that make up the experimental system (Hipólito and van Es 2022). This precludes a claim to objectivity, as different modellers will carve up a system differently. However, this need not be problematic. As we have said before: "to demand an ontology over and above what is relevant to our research interests is to demand an ontology that is epiphenomenal to our investigations" (see Hipólito and van Es, Forthcoming).

This poses issues for realist perspectives on the FEP, which aim to use the formalism as a proxy for the world to be understood. Under a realist reading, model-based findings would have a direct relation to the world under study. The computations used in the model are typically considered equivalent to the computations used by the real-world system it is modelled after; the boundaries established in the formalism would then also map onto real boundaries in the world. These derivations from the FEP are problematized by Raja et al.'s criticism.

Yet an ontologically more parsimonious, 'instrumentalist' approach of the FEP in which the FEP is taken to be an interesting tool for investigations rather than a guide to a metaphysical truth (see e.g. van Es 2020) is not shielded from this criticism either. It seems, following Raja et al.'s paper, that even as a tool for investigations the FEP may be lacking. The onus is then on FEP theorists to show how the FEP can contribute to biological and cognitive sciences.

Acknowledging the co-constructive nature of the FEP helps understanding its contributions. With co-constructive science we mean the following. The various aspects of the experimental system influence and construct one another and the whole dialectically. Not only does the experimenter actively intervene in the system to be studied in its experimentation, but they also construct it by framing it, determining the boundaries of the system of interest, determining what is and isn't of interest. The experimenter is also constructed in virtue of its participation in the experimental environment. Its own behavioural repertoire is directed by the experiment, the system to be studied, and the sociomaterial environment which includes the research group's aims, research conventions and so on (Hesp and Hipólito, 2022).

Co-construction is a historical, temporally thick concept: the current co-constructive processes are themselves constructed (and continue to be constructed) historically. They also construct the future situation. In this sense, co-construction is intended as an expansion of the biological concept of niche construction. By these lights, the current scientific endeavours also impact the practices of other researchers and others beyond the academy. Think of the way publications of results open up further investigations or novel questions, spark new methodological debates or spur on other researchers to incorporate the methodology into their own investigations and explore the possibilities.

Given this perspective on FEP modelling, there are two fruitful, complementary responses to the challenge by Raja et al. 1) We can look outside of the FED's ambitions for applications of the FEP despite these limitations, and simultaneously 2) we can develop the foundational structures of the FEP so as to overcome the limitations. In the former category, Northoff et al. (2022) describe how connecting the FEP with a temporospatial dynamic view of neuro-mental processes could allow us to manufacture 'adaptive agents' that could *augment* instead of *imitate* human behaviours, and help patients navigate troublesome situations based on a database of stored experiences that are flexibly put to use by the free energy minimising system. Similarly, Da Costa et al. (2022) indicate that challenges in robotics such as robustness and planning can be alleviated by implementing the FEP. Fields et al. (2022) use the FEP formalisation of physical interactions as information exchange in conjunction with the development of quantum theory as a scale-free information theory to break new ground in quantum biology. Integration of the entropic brain hypothesis in neuropharmacology (Carhart-Harris 2018) with the FEP has also been helpful in understanding the success of psychedelics in mental health therapy (Hipólito et al., 2022; Carhart-Harris and Friston 2019). These are just a few examples in which the tools and methodologies of the FEP are used and applied beyond its initial intentions to explore novel territory for otherwise unanswered questions. Even without solving the foundational issues that limit the FEP's grander ambitions, then, there remain important contributions to be found in its wider constructive impact.

There is also work that rises up to the latter, foundational issue. Unfortunately, modelling the entire development of the course and dynamics of a living being during their lifespan remains an impossible task due to the high level of complexity. After all, complexity is proportional to the tractability for modelling. This is generally known as the intractability of the posterior in Bayesian inference. This problem calls for dimensionality reduction.[1] As a methodological concession, this common technique in modelling science treats a nonlinear system (i.e. a system whose output is not proportional to the change of the input, therefore chaotic, unpredictable, or counterintuitive) as if it were linear (i.e.the output is proportional to the input) (Hipólito and van Es, 2022).

Yet methods that better encompass complexity can be found in dynamical and complex systems theory. Using the FEP, we can apply Markov blankets in a dynamical setting. For this, we can restrict ourselves and look into a particular moment in time. Using nested Markov blankets, one starts with the acknowledgment of the situatedness of variational dynamics of a behaviour (i.e. that a system's behaviour is situated in a history of continuous flux of interactions with their environment). Any state in time then depends on a set of previous states: those without which the present state would not emerge or exist in the way that it does. The present state density of a system is thus determined by the system dynamics at a previous time (Parr et al. 2021). Simultaneously, it relates to the future in a probabilistic manner (Parr et al. 2020; Hipólito et al. 2021). Thus, while limited to specific, well-defined situations, the FEP researchers are making headway into accommodating historicity. Nonetheless, we concede to Raja et al. that it remains difficult to account for larger scale dynamics and drastic changes over time that we find in many living systems. In this comment, however, we have shown that there remains plenty for the FEP to address, tackle, and influence within and outside of its usual boundaries.

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[1] For a survey of dimensionality reduction techniques see Sorzano (2014).

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