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Abstract In this paper, based on the predictive processing approach to cognition, an enactive theory of need satisfaction is discussed. The theory can be seen as a first step towards a computational cognitive model of need satisfaction.

1 Introduction

Life can be seen as the constant process of satisfaction of needs, and thus numerous need theories have been proposed in humanities and social sciences, such as psychology, economics, philosophy, sociology, anthropology and social policy over the last century (see Human et al, 2017, for some examples). While no consistency can be found in the usage of the term "need" within or across different disciplines (Gasper, 2007), it can be said that most of the conducted research on human needs have been dedicated to development of different categories or lists of needs. Maslow's (1970) hierarchy of needs can be considered as the most famous example of such categorizations of human needs. For sure, such categorizations have had conceptual application in their respective disciplines, however the recent advancements in cognitive science are not reflected in most of them.

In this paper, we reflect on the concepts of *need* and *need satisfaction* from an enactive perspective. Specifically, we take a first step towards development of a

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theory of need satisfaction in *Predictive Processing* (PP) agents. We are aware that one can draw an intimate connection between need satisfaction, and the classical problem of *planning* that has been tackled throughout the history of AI. However, we hope that our reflection based on PP goes beyond the classical approaches, and will contribute to constructing future novel approaches for development of computational cognitive models of need satisfaction or need-based artificial agents.

2 An Enactive PP-based Theory of Need Satisfaction

Over the past decade, there has been a great increase in research based on Bayesian approaches to brain function. According to this approach, which is called predictive processing by Clark (2015), the brain is a probabilistic inference device: a sophisticated hypothesis-testing mechanism that uses hierarchical generative models and seeks to minimise its prediction errors about sensory inputs (Hohwy, 2013). In other words, based on PP, the brain continually and at multiple spatiotemporal scales tries to minimise the error between its predictions of sensory input and the actual incoming input. A wide range of anatomical and physiological aspects of the brain and various cognitive processes has been explained and modelled using the predictive processing approach (Clark, 2013).

How can the concept of *need* be understood from a PP perspective? We can have two approaches to answer this question:

1) From a systemic PP-perspective, any living self-organizing system embodies a predictive generative model in order to ensure that free energy is minimised through action (Calvo and Friston, 2017). Therefore, one can consider, the minimization of free energy (or minimization of surprise) over time, as the basic *need* of any PP-agent. While this radical standpoint could be very inspiring for a general understanding of notions of *life* and *need*, it seems that grounding a computational cognitive model of *need satisfaction* on this general systemic view would be a very difficult task.

2) From a top-down perspective, we can consider needs as general priors (hyperpriors). It is important to emphasise that this view does not preclude other general priors which cannot be considered as needs (such as the general regularities in the physics of the world) (see Hohwy, 2013, p. 116). While this can be considered as a more conservative view, it seems that it provides an appropriate framework for going beyond a purely conceptual understanding of need. Considering needs as general priors enables us to tackle the fundamental question of *how needs are satisfied in a PP-agent?* In other words, by applying this perspective, elements of the PP formal framework (Hohwy, 2012) can be used to model the process of need satisfaction:

(I) *Hierarchy*: The PP mechanism is a general kind of statistical building block that is repeated throughout different cortical levels. The input of each level is conceived as prediction error and what cannot be predicted at one of the levels is passed on the next level. Lower levels of the hierarchy predict basic attributes and causal regularities at very fast time-scales. More complex regularities, at increasingly slower time scales, are dealt with at higher levels. This can potentially provide a formal solution for dealing with different levels of needs, desires, satisfiers, etc (see Human et al, 2017, for a discussion on these notions).

(II) *Contextual probabilities*: Predictions at any level of the hierarchy are subject to contextual modulation. This would provide the appropriate key for dealing with the contextual differences in needs satisfaction.

(III) *Empirical Bayes*: In empirical Bayes, priors are extracted from hierarchical statistical learning. This empowers us to not only model the prior beliefs about needs/satisfiers on a moment to moment basis but also through long-term exposure to individual experience. Furthermore, more hard-wired and instantiated needs, e.g. over evolutionary time-scales, can also be modelled based on the empirical Bayes.

(IV) *Active Inference*: Based on the depth of the represented causal hierarchy, the active inference can be a useful tool for modelling short-term and long-term planning for needs satisfaction.

(V) *Top-down and Bottom-up*: Seeing the bottom-up information as prediction-errors and top-down information as causal models of the world, we can develop a model of needs satisfaction that deeply considers the statistical regularities of the world.

We shall consider all these elements as predictive processing is applied to the problem of need satisfaction. If this is done appropriately, it would be possible to model need satisfaction in a way which (a) is consistent with state-of-the-art in cognitive science such as enactivism, and (b) captures different aspects of need satisfaction such as context-dependency and individual heterogeneities.

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