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Approaches to cognitive modeling

Why emergentist accounts of cognition are more theoretically constraining than structured probability accounts: comment on Griffiths *et al.* and McClelland *et al.*

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Structured probability approaches to cognition aim to reverse-engineer the human mind by identifying ideal solutions to the inductive problems that it faces [1]. Dynamical systems approaches [2] explain cognitive behaviour as the emergent consequence of statistical regularities in the learning environment. Both approaches offer insights into how statistical regularity in the environment can map onto human cognition. However, taken on its own, the ideal solution approach is akin to modelling evolution as a process that has a goal 'in mind', whereby a solution through which to arrive at that goal must be found regardless of the environmental constraints on whether the goal is achievable through the gradual (natural) selection processes that underpin evolution. The dynamical systems approach takes account of both 'exogenous' environmental constraints and (dynamically changing) 'endogenous' constraints on an organism's maturational state to explain how the final state is constrained by these different 'pressures' [3]. In doing so, it also explains two related phenomena that have hitherto been largely overlooked by structured probability approaches: the consequences of sampling the environment across time [4] and the relationship between object representation and probability induction.

One emergentist system that has been well studied is the simple recurrent network [5]; it samples the input with a fixed temporal resolution but is in principle able to allow the emergence of representations that span multiple temporal resolutions (i.e. that capture different kinds of contingency, each across different time frames, between the successive inputs to which the network is exposed) [4]. In effect, hierarchical representation emerges (reflecting systematic variation occurring across different time frames). The adult ability to encode hierarchical representations and multiple contingences across multiple time frames could therefore emerge through the operation of a sampling mechanism that might initially be bound to just a single fixed sampling rate and just a single level of representation (the uninterpreted pattern of activity across the sensory inputs). The emergentist tradition is thus agnostic with respect to the representational units over which probabilities are computed and the rate at which they are sampled. And yet theories of probability induction within the emergentist tradition are a necessary part of the theory of representation (not just what is represented, but also how and why). There is a tight linkage between the two in the structured probability approach, but the process of computing probabilities does not necessarily constrain the nature of the objects over which those probabilities are computed (a consequence of this lack of constraint is the need for a separate mechanism to 'recognize' each such object in the input). In this sense, the emergentist tradition is the theoretically more constraining, and theoretically more constrained, of the two.

The emergentist tradition offers explanatory constraints that are currently lacking within the structured probability tradition. It takes as given the idea that human development and the emergence of adult behaviours pose the critical challenge for a broader understanding of cognition. The critical issue is not whether to start at the top or at the bottom, but whether to start at the beginning.

References

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