DOI:
10.1017/S0140525X12002397

BBS Commentary on: Andy Clark, 'Whatever Next?'

Word Counts

Abstract: 61
Main text: 994
References: 69
Entire text: 1,180

Commentary Title

Perception vs Action: The Computations May Be The Same But The Direction Of Fit Differs

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Abstract

Although predictive coding may offer a computational principle that unifies perception and action, states with different directions of fit are involved (with indicative and imperative contents, respectively). Predictive states are adjusted to fit the world in the course of perception, but in the case of action the corresponding states act as a fixed target towards which the agent adjusts the world.

Main Text

One of the central insights motivating Clark's interest in the potential for predictive coding to provide a unifying computational principle is the fact that it can be the basis of effective algorithms in both the perceptual and motor domains (Eliasmith 2007, 380). That is surprising because perceptual inference in natural settings is based on a rich series of sensory inputs at all times, whereas a natural motor control task only specifies a final outcome. Many variations in the trajectory are irrelevant to achieving the final goal (Todorov and Jordan 2002), a redundancy that is absent from the perceptual inference problem. Despite this disanalogy, the two tasks are instances of the same general mathematical problem (Todorov 2006).

Clark emphasises the "deep unity" between the two problems, which is justified but might serve to obscure an important difference. In the perceptual task a prediction error is used to change expectations so as to match the input whereas, as Clark notes, in the motor task the prediction error is used to drive motor behaviour that changes the input. In perception, prediction error is minimised by changing something internal (expectations) whereas in action prediction error is minimised by changing something external (acting on the world so as to alter sensory input). Although it is true in one sense that there is a common computational principle that does not distinguish between perceptual and motor tasks (§1.5), we should not overlook the fact that those computations are deployed quite differently in the two cases. The state representations in the two cases have what philosophers have called different "directions of fit". Motor tasks take as input goal states, which are held fixed, motor programs for the attainment of which are then calculated (Todorov 2004). These goal states have a world-to-mind direction of fit and imperative content. By contrast the state descriptions in the perceptual task (expectations fed back from higher levels in the processing hierarchy) are continually adjusted so as to match the current sensory input more closely. They display a mind-to-world direction of fit and have indicative content. The difference is apparent in its consequences for the behaviour of the organism: prediction errors in respect of indicative representations can be fully cancelled without the agent having to perform any action, whereas prediction errors in respect of imperative representations cannot be cancelled unless the agent moves in some way.

If these accounts are right, then the deep unity consists in the fact that both perception and action involve the reduction of prediction error. However, since they do so by quite different means, a deep difference between perception and action remains. Some sensorimotor accounts of our interactions with the world do indeed serve to dissolve the boundary between perception and action (Hurley 1998), but the predictive coding framework on its own does not. (It does however undermine a clear boundary between perception and cognition.) This gives rise to an important question for the predictive coding programme: what determines whether a given prediction / expectation is given a mind-to-world direction of fit, allowing it to be adjusted in the light of prediction errors, and what gives other expectations a world-to-mind functional role, such that prediction errors cause bodily movements / action? As the evidence for a common computational principle in perception and action mounts, the need becomes pressing to specify how this fundamental difference between its two modes of operation arises.

Clark goes on to consider whether an austere 'desert landscape' description of the computational processing is possible that does away with goals and reward entirely (§5.1), in the sense that neither are represented in the model. If action guidance requires states with a world-to-mind direction of fit, then states which function as goals have not been eliminated. Even if the difference is a matter of degree, with many cases in the middle, we are still operating with a continuum marked by the extent to which a state operates as a goal state at one end or as an indicative state at the other.

The distinction between indicative and imperative contents also throws light on the darkened room problem: why don't agents minimise prediction error by just sitting still in a darkened room? If some subsystems are constrained to minimise prediction error not by changing expectations but by acting, then sitting still in a darkened room will be entirely ineffective in reducing such error signals. For example, if the there is one of these goal state representations for the level of sugar in the blood, when sensory feedback fails to match the target the agent does not have the option of reducing the error signal by changing its expectation; instead the agent must act so as to change the sensory feedback (i.e. to increase the level of sugar in the blood). This answer is complementary to Clark's observation that some forms of prior expectation could lead agents to engage in exploratory actions or social play – the need for imperative representations is orthogonal to the distinction between exploratory and exploitative actions (which can, in any event, only be drawn relative to some set of goal states).

A final observation concerns the question of whether the expectations involved in predictive coding calculations refer to the external world. It is sometimes suggested that predictions and prediction errors only concern the states of other computational elements in the system. Goal states are perhaps the most obvious candidate for representations that refer to the external world. Since the feedback to which they are compared is changed by action on the world, it is plausible that they come to represent the external world affairs that must be changed if the prediction error is to be cancelled.

To conclude, Clark's persuasive case for the importance of predictive coding as a unifying computational principle, like any fruitful research agenda, brings new issues into focus. An important one is the question of what makes that computational principle operate in indicative (perceptual) mode in some subsystems and in imperative (action) mode in others.

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