

Predictive processing mind models vs. the binding problem

Predictive processing mind models (PPMMs) can, according to advocates such as Jakob Hohwy, account for the binding of visual percepts in their set-up. However, these arguments suffer from their lack of taking into account the necessary flexibility the model would need to possess in order to incorporate all of the differing types and aspects of visual binding. In working towards a conception of PPMM which can avoid running into these difficulties, I anticipate a model which does not bind visual percepts but performs operations on an already-bound visual world. However, before defining the specifics of either the model or the nature of the operations, it is necessary to try and construct a solid argument as to exactly how the visual world might be bound without the need for internal brain mechanisms to perform the binding. This talk will take two approaches as to how that argument might be constructed. Firstly, a cognitive science-based approach which examines and critiques those positions in which binding has already taken place in order to ascertain whether it is a coherent line to take. In this instance, I will look at Anne Treisman's attentional window hypothesis, and highlight some of the issues and problems surrounding it. Secondly, there should be a philosophical approach in which the prospect of world-centred binding is given a convincing metaphysical grounding. To this end, I will examine Donald Hoffman's interface theory of perception and question whether aspects of it can be reversed to suggest that, contrary to Hoffman's position, we can access something akin to an objective, bound reality. I conclude by noting that if one could combine a watertight cognitive science-based argument as to why visual binding did not depend on internal brain mechanisms with an equally fleshed-out metaphysics that pointed towards 'the world taking care of itself', then one would have a solid theoretical base for proceeding with a reworking of the PPMM model.

PPM models: a general overview

- Philosophically, they attempt an answer to the problem of induction – how we can make correct inferences from sparse information.
- Technically, they propose a top-down neural network that sends a downward flow of predictions on the state of the world that interacts with the upward-flowing sensory signal of real-world information.
- They are ‘prediction-first’ – the top-down predictions perform the bulk of the work, and all that is sent back upwards is the error signal when a prediction is proved wrong.
- The error signals are then incorporated into the predictions, so the predictions become ever more nuanced.

PPM models: a general overview contd.

- The cycle of prediction is perpetual and sub-personal – PPMMs conceive of the brain as being continually engaged in making predictions about its environment, never merely reacting to it.
- The cycle is also repeated across all levels in the hierarchy simultaneously.
- The hierarchical levels are multiple levels of processing which allow the network to train itself – the prior predictions at the higher levels place constraints on the levels below, so the most likely priors above function as the current priors for further down, while the whole is tuned by the error signal.

Hohwy's model incorporating visual binding

- Jakob Hohwy's PPMM incorporates the binding of visual percepts in a manner which avoids the pitfalls of brain-based binding mechanisms – the possibly fruitless search for neural correlates of those mechanisms, and the risk of combinatorial explosion.
- The model assumes the existence of bound visual percepts as a highly likely prior probability, and queries the bottom-up sensory information it receives on the basis of this probability.
- The network is based on minimising prediction error and will not proceed on an incorrect prediction.
- Bound visual percepts are not only correct but so inescapably correct that they become core predictions, which subsequent predictions can be based upon. Binding is perceptual inference.

Problems with Hohwy's model

- There are no known neural correlates with the sort of network he describes. (This is a problem for all PPMs.)
- Further to this, there is a gap between what Hohwy's model says is possible *in theory*, and what a lab-based training network could tell us. Hohwy doesn't explain how the theoretical could become practical.
- E.g., a laboratory network could bind 'red' to 'circle' but not possess a generative model allowing it to hold onto (colour + shape) as a prior.
- The model concentrates on causal binding (e.g., red + circle) but ignores other binding types such as logical/semantic binding (e.g., the sentence "This circle is red", which communicates the same meaning in a different modality).

What if visual binding was world-based? (instead of brain-based)

Advantages:

- Takes pressure off the search for internal binding mechanisms.
- Makes evolutionary sense, as it would free up organisms to concentrate on cognitive tasks other than binding.
- Makes intuitive sense, as objects in the world surely do not rely on the gazes of organisms to bind their properties together.

Disadvantages:

- May undermine the need for any kind of PPM model – a simpler ‘bottom-up’ model would be fine if all that’s needed is to reflect reality.
- Does not seem to allow for the complexity of bound reality – there may have to be some internal filtering mechanism in order that the brain doesn’t become overwhelmed.

An alternative: the attention window hypothesis (Treisman)

- Feature integration theory: different visual properties form different ‘feature maps’ and are registered by the system paying attention to their locations.
- Feature maps code the type of property but not the location, and a ‘master map’ codes the location but not the type of property.
- The attention window exploits the master map’s connections to the feature maps, retrieving the properties via the locations, and also exploits the fact that properties sharing a location are likely to belong to the same object.
- The window excludes distracting elements from its field; so as long as attention is paid, the elements in the window are already bound.
- “Scanning with focussed attention would then be a process, not of binding features together from scratch, but of checking and correcting the conjunctions (*i.e., of location + properties*) that have spontaneously formed.”

Problems with the attention window hypothesis

- Can be read just as much as showing an internal binding mechanism as not.
- Does it hang too much on how literally you are prepared to take the 'window' metaphor as opposed to the 'spotlight' one?
- Glyn Humphreys: looking at the effects of types of brain damage, the results can be very specific; only certain aspects of vision are affected. E.g., showing good binding of shapes, but surface properties tend to migrate between shapes (Balint's syndrome).
- This suggests that visual binding may be something multi-faceted that occurs in differently processed stages, whereas Treisman's thesis would have binding occurring in a single (attentional) "shot".

The interface theory of perception

- Principle of Faithful Depiction: that the primary goal of perception is the recovery of objective facts about the world, which is what lies behind the PPM approach.
- The interface theory denies this: natural selection is only concerned with the fitness-for-purpose of an organism to its environment, not with objectivity.
- Perceptions are an interface between the organism and the objective world. They are not reconstructions of reality as it is, and are useful precisely *because* they are not reconstructions.
- Each species has its own interface and sometimes it goes wrong – e.g., Australian jewel beetles attempting to mate with beer bottles. Their interface seems to be concerned mostly with colour/surface textures.

Can we accommodate the interface theory?

- Hoffman admits to objective reality – he compares the perceptual interfaces to computer desktop icons hiding the complexity of their functions while allowing us to use those functions. The hidden complexity, on this reading, is the objective reality.
- So on the one hand, we could think of the objective reality as ‘the world taking care of itself’ and on the other, we could think of the interfaces as the organisms’ individual internal binding mechanisms.
- Can we access the objective reality to make comparisons – e.g., to highlight what the jewel beetle gets wrong? According to Hoffman, no, because our pointing this out is from the point of view of our own interface, not reality.
- Is it *necessary* to accommodate the interface theory? Why couldn’t we just reframe PPMMs as a type of interface machine? (It may be that the Principle of Faithful Depiction is a mischaracterisation of what PPMMs are supposed to do.)

Selected bibliography

- Clark, Andy; *Mindware*; Oxford University Press; second ed., 2014
- Clark, Andy; 'Whatever Next?: Predictive brains, situated agents and the future of cognitive science'; *Behavioural and Brain Sciences* 36 (3); 2013
- Hoffman, Donald D.; 'The Interface Theory of Perception: Natural Selection Drives True Perception to Swift Extinction'; *Psychonomic Bulletin and Review* 22 (6); 2015
- Hohwy, Jakob; *The Predictive Mind*; Oxford University Press; 2013
- Humphreys, Glyn W.; 'Conscious visual representations built from multiple binding processes: Evidence from Neuropsychology'; from *The Unity of Consciousness: Binding, Integration and Dissociation* (ed. Axel Cleeremans); Oxford University Press; 2003
- Treisman, Anne; 'Consciousness and Perceptual Binding'; from *The Unity of Consciousness: Binding, Integration and Dissociation* (ed. Axel Cleeremans); Oxford University Press; 2003