Article

On Modelling the World: Some General Principles

Chris Nunn*

Abstract

Neural models of the world, and of ourselves in the world, may best be pictured as representations of the 'content' of dynamic state spaces that encompass bodies and environments along with brains. These neural representations must be fractally structured and are viewed as consisting in the dynamic patterning of ionic shifts with their associated e-m fields. Calcium ion dynamics is likely to be especially important to modelling because of its roles in memory formation. Memories are regarded as 'attractors' in the dynamic state space of mind that mould re-creation of particular neural models. It is further suggested that *conscious* modelling is a property of what might be termed a structural or topological aspect of temporality that has a non-commutative relation to the patterning of (a proportion of) the energy eigenstates that subserve neural modelling.

Keywords: General principle, model, world, neural representation, brain, memory formation, consciousness, ionic shift, dynamic pattern, E.M. Field.

1. Introduction

Brains make models of their worlds and of their own activities, some of which we experience in our streams of consciousness. Indeed each of us, viewed as an individual conscious self, ***is*** the model we have made of our own body and history, constantly updated as time rolls on and memories accumulate. How can we most usefully model the modelling that allows brains to image their worlds along with their own activities? Artists and many novelists are makers of representations of brain-made images that often fascinate with their beauty and insightfulness but are descriptive only. Musicians and poets may produce truer correspondences, so our intuitions often tell us, though ones so indirect that they are hard to conceptualise. Our best option, when it comes to seeking an understanding of the nature of these models, is to turn to science while hoping to evade metaphysical issues insofar as they can be evaded; they can't be escaped altogether mainly because of problems arising from the incompleteness of both quantum field theory and general relativity but I'll try to deal with them as clearly as possible in what follows.

The major difficulty for neuroscience, when it comes to formulating models of brain models, is that it's faced with impenetrable thickets of complexity. To name some of these: at least 50 different chemicals are produced to trigger or modulate mind-relevant nerve cell activity, many

* Correspondence: Chris Nunn, Psychiatrist & associate editor of Journal of Consciousness Studies, UK.
Email: cmhnunn@btinternet.com

of which affect more than one type of cell receptor; then there are complex hierarchies of (mostly 'small world') anatomical networks which reciprocally affect one another; to confuse matters further the tiny dendritic spines that mediate most nerve cell connectivity are as motile as waterweed in a turbulent river, while so-called 'gap junctions' can open up between components of formerly separate brain cells and then close again at the behest of a range of influences; to add to the problems, it has recently been found that brain cells are far more various than previously supposed in that thousands of varieties can be distinguished by their differing epigenetic make-ups. In brief, recent hopes that elucidating 'connectomes', for example, might allow the development of anything more than very partial models of brain modelling were never more than pipe dreams, if only because brain systems are in constant flux over time scales ranging from milliseconds to years.

A good first step towards developing a comprehensive picture of how brains do what they do involves asking two very general questions; (a) what exactly is it that brains model? (b) what do they do with their models? We often suppose that the answer to the first question is that they register information in memory stores, about the structure of that face over there for example or the sequence of sound frequencies in a song or the sensations associated with task performance, and then perform some sort of functional operation on the recorded information that results in a representation of its meaning.

It's a popular conception inspired by computer metaphors for mind. But what's actually happening in the case of seeing a face is that aspects of the dynamics of light reflectance from the face are integrated, via a long series of intermediate steps, into the dynamics of neural activity in the brain. Any idea of 'information' is relevant only in the broadest (Batesonian) sense of its referring to 'differences that make differences'. Although a few specialized functions, those of the hippocampus in particular, can and have been modelled via digital computational modelling of representations of 'information processing' by neural nets, most brain activity relates to 'gestalts' that have already integrated the dynamics of aspects of its environment into those of the brain.

Similar 'integration' occurs, not only in relation to the dynamics of the world out there but also, because of its 'small world' connectivity, to dynamics within the brain. Brain 'models' whether of their environment, the bodies that harbour them or their own internal activities are always dynamic happenings 'resonating' (Grossberg 2021) with other dynamic happenings. If one were to offer a (somewhat misleading) computer analogy, these models correspond to the ever-changing content of RAMs, not to the rigid architecture of ROMs.

However the occurrence of models does get remembered in forms that allow their resurrection when contexts are appropriate. And that's what brains do with them; they facilitate model perpetuation and/or recreation, using outcomes to predict the likely future course of particular sets of dynamic happenings. This happens over timescales of milliseconds in the context of playing a sport to years in the case of studying for a PhD. Learning is a process of refining accuracy of model re-construction in order to optimise predictions. Given these answers to the two questions posed earlier, what do they imply about the detail of mind-relevant neural functioning?

2. Cloudscapes of the mind

A sometimes useful way of picturing extremely complex dynamic systems is in terms of dynamic state spaces where each causative vector is assigned a separate 'dimension' (so that 6 'dimensions' must be assigned in relation to many individual types of cause). The resultant notional 'space' can have an almost infinite number of 'dimensions', especially in the case of most brain-related state spaces, though at least the number is not actually infinite as it is with the 'Hilbert space' occupied by quantum field theory. When the space includes many non-linear feedback events, it will represent a chaotic dynamic containing the inevitable 'attractors' that will look (in imagination of course!) like a hugely complicated, ever evolving cloudscape containing 'castles' of every variety. The 'clouds' themselves correspond to the 'shapes' of the brain dynamics that provide models of the world.

The attractors responsible for clouds correspond to memories that accompany cloud formation or shape re-formation. They too will have 'topologies', but ones more analogous to those in meteorological charts than to those of the 'clouds' themselves. Since most will have Lyapunov exponents > 0 they will usually be 'strange', owning all sorts of weird and wonderful forms. Indeed memories can be thought of as Aristotelean *formal* causes, or even as comprising local 'natural laws' in relation to brain dynamics, according to this picture.

The usefulness of this rather fanciful way of picturing brain dynamics lies in its implications for the nature of neural events likely to prove most directly relevant to our brains 'mental' functioning. One of the most important implications is that the dynamics of brain modelling must be fractal over a very wide range of both temporal and spatial scales. The huge notional dimensionality of the content of dynamic state spaces can 'translate' into real, spacetime dynamics only in the form of fractals or pseudo-fractals (where the fractal dimension itself varies between scales).

To get a 'feel' for why this should be so, it's worth looking at images of rotating tesseracts (available on Wikipaedia). Tesseracts are very simple shapes - notional four dimensional cubes - but their representations on the two dimensional surface of a laptop screen undergo complicated nested changes as they are shown to rotate; now imagine what a billion dimensional 'cloud' would look like when represented in a three dimensional brain! This implication of fractality puts quite severe constraints on three aspects in particular, namely the 'whats', 'wheres' and 'hows', of any ideas about theoretical models that might realistically represent actual neural models of the world. I'll try to deal with these three issues in sequence.

3. What models the world?

This question has a fairly straightforward general answer, though there's plenty of devil in the detail (see e.g. Grossman 2021 for a 'state of the art' account of detail that needs to be taken into account). The only good candidate able to embody the required fractality, given our current understanding of neuroscience, has to be 'patterned ion concentration changes along with their associated e-m fields'. Some of these changes (i.e. those resulting in action potentials) enable transmission of dynamic modifications over long distances. It's interesting in this connection that only about 10% of synaptic inputs to primary visual cortex neurons originate from retinal sources. The rest are from recurrent intra-brain sources implying that, even in the case of 'straightforward' visual perception, most of the modelling originates in intra-brain modification of direct 'translation' of the dynamics of the world out there.

Ions principally involved include sodium, potassium, chlorine, calcium and magnesium. Of these, calcium ions are likely to be the most directly involved in model building for two reasons. First, they're known to undergo structured, often wavelike, concentration changes on scales ranging from that of dendritic spines, through entire nerve cells to macroscopic volumes of neuropil (i.e. dendritic plexi which include contributions from both neurons and astrocytes). Larger scale patterning still is achieved by nerve firing and its 'projection' of smaller scales onto a broader, electromagnetic field, 'canvas'. Second, locally increasing calcium ion concentration activates a group of related enzymes (CaMKll enzymes which comprise around 1.5% of *all* protein in the brain) that have important functions in relation to memory formation. It follows that patterns of increased calcium ion concentration can be regarded as principal actors in the translation of 'cloud' models into the 'attractors' which enable their resurrection.

However the generality of ionic concentration changes have only local consequences which may contribute to wave-like forms, as the huge body of EEG and related recording methodologies in both clinical and research contexts shows us at scales ranging from intra-cellular to whole brain. This in turn suggests that interference effects of various sorts could be important to modelling, maybe even allowing a form of holography to be important to the 'reconstruction' of models via the operation of memory (see e.g. Adrade-Talavera et al. 2023 for a good account of the likely importance of ion shift timing to brain function). All holograms are fractal, though not all fractals are holograms, which additionally implies that the never-quite-mainstream idea (advocated by Carl Pribram and Walter Freeman in particular before they died) that holography is relevant to brain modelling may well be worth re-visiting.

As mentioned earlier, there are two main reasons for supposing that calcium ions are principal actors in the dance. The first is to do with the fractal structure of the modelling process. Local, ordered changes in calcium ion concentration are known to occur on scales ranging from those of dendritic spines to entire cell bodies. If brain modelling is fractal, there must be a scale supported by structures intermediate between individual neurons and entire neural networks. Astrocytic 'domains' are examples of such structures and astrocytes are now known to have important roles in 'mental' functioning (e.g. Murphy-Royal et al., 2023), while it's also known that they harbour wavelike changes in calcium ion concentration able to traverse groups of these cells along with the neural dendrites with which they link. This faculty is probably mediated mainly by gap junctions between both neighbouring astrocytes and the neural dendrites in their 'domains', which can reversibly turn these entities into giant cells analogous to the more permanent syncytia of striped muscle.

The second and more cogent reason has to do with the fact that local increases in calcium ion concentration act as a sort of rheostat tuning up the duration of activation of CaMKll enzymes until it reaches a plateau. This in itself provides a form of memory while the activated enzyme triggers a range of further permanent or semi-permanent modifications of neural connectivity and functionality. Modelling by the dynamics of calcium ions can thus be thought of as a principal, though probably not the only, generator of new attractors able to 'resurrect' the modelling when contexts are favourable.

It has proved notoriously difficult to source any definite sites for long-term memory storage in the brain. According to the picture offered above that's because they mostly depend on the formation of strange attractors with very complex topologies that 'guide' the formation of the dynamic models that manifest as memories. Which leads to our second question; the one about where these models should be thought to exist.

4. Where are models of the world?

This question has a straightforward answer in the case of those that are recalled and responsible for any of the varieties of memory that we experience. Clearly they are 'in the brain' in some form or other. However the models 'themselves' are of a dynamic that often encompasses bodies and extensive features of environments along with brains. Therefore there is a valid sense in which that's where they are, from an epistemic point of view at least.

This may sound contrived but it is perhaps the only way, as Max Velmans (e.g. 2008) pointed out when elaborating his concept of 'reflexive monism', of understanding why a pain in your toe should appear to be in your toe rather than in the sensory cortex of your brain or in no particular place at all, or why familiar tools should feel like 'natural' extensions of our own bodies. It offers routes, too, to understanding 'group mind' phenomena such as mob violence along, perhaps, with some of the phenomenology associated with love or with extravertive mystical experience. But it also highlights the 'how' question. How could these models possibly manifest, as many of them do, in the phenomenology that we experience?

5. How do phenomenal models occur?

All that's been said so far relates to 'objective' neural models. But of course the only models of the world and our own selves that we can directly experience are the mainly qualitative phenomena that manifest in the flow of 'subjective' consciousness. Further, the only ones that we can recall having experienced are those that have managed somehow to develop into attractors in the dynamic state spaces of mind.

A plausible account of how this is possible starts with a question about a curious omission from our most complete theory of matter, namely quantum field theory, which can be used to model (at least 'in principle') all known features of the material world *except* for time and conscious phenomenology. If string and loop quantum gravity models are regarded as separate from quantum theory, which is a reasonable view to take as things stand at present, gravity has to be included along with the other two. All of these, of course, are among the most important properties of the world as far as we are concerned and we're not going to understand any of them unless we can develop adequate models of them.

The starter question to ask in connection with conscious phenomenology is: 'why is position in time, unlike position in space, *not* a quantum observable?' And it has a fairly obvious answer, since 'observation' in this context refers to the 'measurements' (whether envisaged in terms of any of the current theories of it, including von Neumann, Bohmian, decoherence or transactional ones) which produce 'eigenstates'. If position in time is not itself a quantum 'observable' then the simplest explanation is to suppose that acquisition of it *enables or comprises* 'observation'.

The mathematical models themselves imply a similar conclusion since quantum field theory is compatible with special (though not with general) relativity, and the temporal 't' variable of special relativity is usually taken to be negative relative to the spatial, 'x,y,z' values. Negative quantities can only be inferred, not directly observed, so it's hardly surprising that temporal position is not among quantum observables but is acquired in the course of observation.

Quantum theory does encompass features relating to temporality, though not directly to the 'clock time' of relativity theory which is a metric emergent from the dynamics of the post-'measurement' world. Indeed there is a model, due to Charles Francis (2023), which formally shows spacetime structure to be pre-figured in the Feynman diagrams that relate to electromagnetic force. One of the intrinsic features involving temporality is to do with the notional (de Broglie) *frequencies* attributable to all quantum particles or entangled states. In the case of photons, but not in that of other particles, de Broglie 'frequencies' correspond to those directly measured because massless particles don't possess any intrinsic clock-time temporality. Whether directly measured or not, these 'frequencies' correlate with the magnitude of energy eigenstates that manifest following 'measurement'.

The other significant feature is that energy eigenstate 'measurement' precision has a non-commuting (Heisenberg uncertainty) relation to the precision of any clock-time position measurements that may be made. One implication of this is that there must exist a sort of 'hum' of temporality pervading the universe in much the same way as the 'vacuum energy' that is such a popular concept at present is supposedly constituted of a sort of universal soup of virtual particles. A further implication is that this temporality is quantized into durational 'chunks', conceptually similar to the virtual particles of quantum field theory.

The usual assumption would be that any quantized 'chunks' of duration can be modelled by units of Planck time, but that can't be right because Planck time is defined as the time it would take for light to traverse the Planck distance. In fact, if any photon could be confined to the Planck distance, it would be at least as energetic on its own as a whole galaxy's worth of 'normal' photons. In any case, clock-time duration is not something that could directly be measured by *any* photon since relativity theory tells us that durational extension isn't a property intrinsic to them; it's something emergent, measurable by observers from their observations of any causative relationships that a photon might mediate. The idea that a Planck duration might meaningfully exist somehow is, in other words, wholly unrealistic.

The clock time durations reciprocally associated with the 'uncertainty' of energy eigenstate 'observation', on the other hand, are real in some sense and have especially interesting implications for dynamic modelling. I'll refer to them with a neologism, 'horation'[1], in what follows in order to avoid too much repetition of some cumbersome phrase like 'durations associated with the temporal uncertainties involved in the non-commuting relation between time and energy 'measurements' that are referred to as Heisenberg uncertainties'.

Most horations will be so brief as to make no detectable difference to the temporal characteristics of the world; they will just contribute to the background 'hum' of temporality mentioned earlier. But complex, low entropy, low energy systems like brains will harbour large numbers with appreciable magnitudes since many of the energetic events relating to the system dynamics come with a very small intrinsic energy uncertainty – ion bindings, for example, or possibly bio-photon or phonon related events. In fact horation magnitudes in brains especially can be expected to extend up into the range of EEG frequencies, reaching as much as 0.1 seconds perhaps.

As the brain's dynamic modelling is a function of the causative, energetic events within it, horations will inevitably instantiate the same modelling in patterns of duration; in patterns of temporality in other words. Since achievement of a position in time is what *comprises* 'observation', according to the model developed here, it's tempting indeed to suppose that horational patternings can be identified with the content of consciousness. It would then be natural to think that both they, and consciousness itself, are in some sense 'imaginary'. On the other hand, since they are pictured here as providing organisation of a temporal positionality that

[1] I originally wanted to use the term 'huration', substituting 'h' for Heisenberg for 'd' for distance in 'duration'. However horation, implying a process of creation of hours, gives a much better feeling for its intended meaning. Many thanks to Cathy Reason for suggesting it.

enables manifestation of eigenstates, it would be equally reasonable regard the manifest world as a *product* of 'imagination', consistently with the Hindu concept of 'Maya'.

At least the model is testable in principle (Nunn, 2019) since patterns of horation can be expected to modify the apparent timing of averaged energy eigenstate manifestations sufficiently to affect brain rhythmicity. It should be possible, therefore, to detect an 'invisible' energy source or sink at work in the brain which would look like a violator of energy conservation over periods of up to 0.1 secs definitely, and maybe for far longer given that the fractal 'structure' of neural models is supposedly replicated in horational ones.

There are lots of questions that could be asked in this connection, but I'd like to end up with a brief discussion of just one of them: what sort of co-ordinate system should be used in connection with horational models? They surely preserve topologies, but do they preserve the spacetime dimensionality of neural models?

6. The dimensionality of conscious models

Lots of people, in discussion groups and elsewhere, are currently tiptoeing around the 'life after death' question, partly through existential angst but also because of questions raised by the occurrence of eidetic memory along with reports of near death experience, terminal lucidity, documentation of children's apparent recall of a 'past life' and the like; many of these reports are individually hard to explain away and harder still to explain away as a group of apparently related phenomena (see e.g. Moreira-Almeida et al. 2022). The model offered here strongly suggests that much of the confusion surrounding this issue could be down to use of the word 'after' in the life-after-death question, which implies occupancy of a 'life' in some sort of extension of our relativistic spacetime continuum.

The model of conscious experience and selfhood proposed here, however, is 'made' of structured actual durations (here termed 'horations') whose main characteristic is that they enable, or at least accompany, the present manifestation of everything belonging to the world. Their essential quality is one of 'presence'. Futurity may add to their number and complexity of organisation as time passes from our point of view, while 'past' refers to states of reduced number and complexity, but the states themselves must still be regarded as retaining their quality of 'presence'.

The co-ordinate system applying to the model must therefore be similar to that applying to quantum entanglement relations, at least as far as temporality is concerned. It will have more in common with a description of 'points' on a delineation of Platonic forms than with those relating to a flight from London to New York. But whether the detailed patterning of 'presence' is lost or changes as the future adds in more of it remains an open question. It would not be unreasonable to suppose that additions might be incorporated into any structure of 'presence', rather as happens in the case of neural models as we develop. Maybe the conscious patternings of 'presence' can evolve, even in the absence of a brain to help mould them – and maybe Einstein was right to say that the apparent disappearance of the past is only "a stubbornly persistent illusion", at least in the case of what subserves conscious selfhood and perhaps much more widely. Time will tell, maybe, in a more literal sense than is usually assumed!

Acknowledgements: If I were to fairly acknowledge and list of all my sources, I'd probably have to exceed Helen Dunbar's total of some 5000 references given in her monumental book on psychosomatic medicine. But that was written in a more leisurely age (the 1950s). To attempt the same inclusiveness now would invite instant deletion from laptops and from any would-be reader's memory, so I've included only a few examples here and would like to offer a general 'thanks to all of you' to everyone else.

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