



DMT AND THE TOPOLOGY OF REALITY

by Andrew Gallimore

*If the outside world fell in ruins, one of us would be
capable of building it up again, for mountain and
stream, tree and leaf, root and blossom, all that is
shaped by nature lies modelled in us*

- Hermann Hesse

It's quite remarkable that Hermann Hesse wrote these words almost a hundred years ago, in his semi-autobiographical novel, *Demian*, and yet they beautifully capture our current understanding of brain's role in modelling the world – all that appears in the world is modelled in our brains. It is no coincidence that the novel's protagonist, Emil Sinclair, describes growing up in what he calls a *Scheinwelt* - a world of illusion. Hesse was deeply fascinated by Eastern thought and, according to Vedic and Buddhist philosophy, the phenomenal world is indeed an illusion (*maya*). It is comforting to see the world around us as being somehow fixed, solid and, most importantly, *real*. But it only takes a lungful of N,N-dimethyltryptamine (DMT) to shatter this delusion. Whether the external world-in-itself, the noumenal world, is truly *real* is difficult to answer and, for the purposes of this discussion, it really doesn't matter. The only world we can ever experience is the phenomenal world – the world that appears to consciousness. As far as we know, the phenomenal world is never transcendent – it never reaches out and touches the noumenal world; it is always in the head. Thomas Metzinger (2009) expresses it clearly:





The global model of reality constructed by our brain is updated at such great speed and with such reliability that we generally do not experience it as a model. For us, phenomenal reality is not a simulational space constructed by our brains; in a direct and experientially untranscendable manner, it is the world we live in.

For most people and for most of the time, this phenomenal world appears stable and predictable, but only because the brain has evolved to generate a stable and predictable model of the noumenal world. However, psychedelic drugs, such as DMT, LSD and psilocybin, among others, not only show us that the phenomenal world can become fluid, unpredictable and novel, but that it can be annihilated in an instant and replaced with a world altogether stranger than anything we can imagine. It is tempting to regard such perceptual aberrations as just that – ‘tricks of the mind’, hallucinations, illusions or, if we want to appear especially smart, ‘false perceptions’. But such a self-assured attitude is hard to justify, as deciding what is true and what is false about our perceptions is far from trivial. To regard the phenomenal world as a stable and fixed entity is really just an approximation and as we begin to discover and explore worlds of astonishing beauty, complexity and strangeness, this approximation becomes less and less useful as a general model of our reality. Whilst the consensus model of reality is certainly the most informative from an adaptive standpoint, there is no reason to assume that it is the only informative model in an absolute sense and so no reason to dismiss those versions of reality that transcend our standard frame of reference.

The phenomenal world appears as a single unified experience that cannot be broken down into its constituent parts and yet, at the same time, contains a massive amount of information that enables us to distinguish each moment from the one that preceded it. Every single moment of our lives, whether waking or dreaming or under the influence of a psychedelic drug, is different from the last. This might seem obvious, but is only the case because the brain is capable of generating a practically infinite number of conscious moments, worlds if you like, each different from the last.

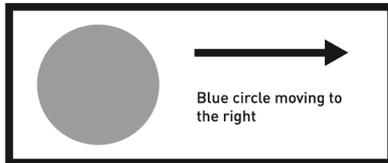
The brain achieves this using the principle of *functional*



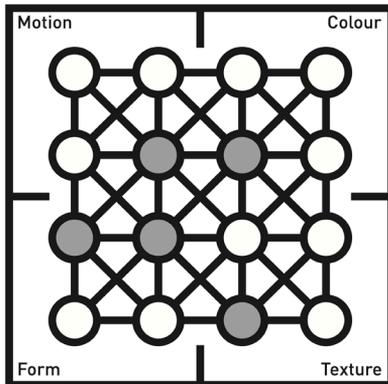


segregation, which refers to the way specific areas of the cortex are responsible for specific functions (Nelson *et al* 2010). As we are primarily visual creatures, we will use an example from the visual system to explain how this works. To generate a visual scene, different areas of the cortex have specific roles in representing different features of the phenomenal world. There are specialised regions devoted to orientation, direction of motion, colour and form, for example. The primary visual cortex (denoted V1) sits at the back of the brain, in the occipital lobe. It is this region that receives visual information from the external world first, from the retina at the back of the eye and via the thalamus. V1 is generally responsible for basic visual features, containing ‘simple’ neurons that are tuned to respond to specific line orientations and spatial frequencies, as well as more ‘complex’ neurons that only respond when a line is moving in a specific direction, for example (Snowden, Thompson, & Troscianko 2006). From V1, the information is passed to the visual association cortex, which contains areas specialised to represent specific features of the world, such as geometric shapes, colours and spatial depth. Further downstream are areas specialised for the recognition of specific types of objects, such as faces or animals.

Fig. 1 Functional segregation in the visual cortices



Perceived visual object



Cortical representation

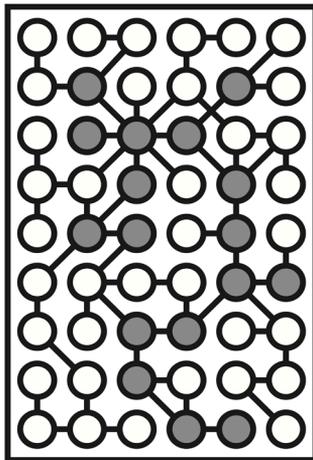
As a simple example, we can imagine how a highly simplified brain, containing just a few functional areas, would represent a simple object, such as a blue circle moving from left to right. The outline and shape of the circle are represented in one area of the cortex, whereas its colour and movement are represented in the areas specialised for those specific functions. In a real human brain, the mechanism is analogous – different functionally segregated areas of the cortex are responsible for mapping the basic features, such as the edges, contours and their orientations, as well as the





overall form of the object, its colour and movement (Fig. 1). All of these individual characteristics, each represented by a specific functional region of the cortex, when combined, define a moving blue circle, which is itself a pattern of activation in the cortex. Complex objects can be represented by specific patterns of activation of functionally specific areas of the cortex and, overall, the world that appears in consciousness is an extraordinarily complex pattern of activation of functionally segregated areas of the cortex.

Fig. 2. Pattern of activation of functionally segregated areas of the cortex.



Functional segregation in the brain is so fine that an effectively infinite number of combinations is possible.



informational structure of the phenomenal world from moment to moment – the world is built anew with every moment, each thalamocortical state different from the last. The cortex comprises billions of columns, allowing it to generate a practically infinite number of phenomenal worlds (Fig. 2). However, it is obvious that the brain tends to adopt a very specific set of thalamocortical states; these are the states that model the consensus world. In fact, even when dreaming, the brain tends to model the consensus world as a default. The majority of dreams are of this world and most dream activities are those from waking life (Schredl & Hofmann 2003). The thalamocortical states that generate the dream state are identical to those of waking – the brain is modelling the world in exactly the same way, despite having

The functional segregation is, of course, much finer than the simple gross distinctions between shape, colour, movement, etc. In fact, the human cortex is often described as a mosaic of minimal functional areas known as thalamocortical columns (the thalamo- prefix is from *thalamus*, the hub structure in the centre of the brain and with which the cortex is heavily interconnected). These are thought to be the basic unit of functional segregation in the brain (Hirsch & Martinez 2006).

It is the patterns of activation of these columns, or ‘thalamocortical states’, that represent the





no access to sensory data from the external world. This raises the question as to why the brain is capable of doing this with such adroit. The answer is rather simple – even when awake, only a small fraction of the information used to model the world actually comes from sensory data, known as *extrinsic information*. Most of the information results from ongoing activity of the thalamocortical system, known as *intrinsic information*. Sensory data doesn't create the world, but rather, modulates this ongoing activity by being *matched* to it (Tononi, Sporns & Edelman 1996; Edelman 2000; Sporns 2011). The waking phenomenal world is most aptly described as a waking dream that is modulated or constrained by extrinsic sensory data (Behrendt 2003). This is perhaps a little surprising, but explains why the brain can model the world with such expert precision during dreaming. The brain's model of the world is generated by intrinsic thalamocortical activity, modulated but not created by sensory data (Llinas, Ribary, Contreras, & Pedroarena 1998). To understand how the brain evolved to model the world so effortlessly, we need to understand a little more about the structure of the thalamocortical system and its neuroevolution.

So far, we have considered the thalamocortical columns of the brain as independent structures. However, in reality, the columns are heavily interconnected and the activation of a single column can influence the activity of many columns to which it is either directly or indirectly connected. This connectivity is a key feature of the thalamocortical system, because it allows the brain to generate specific patterns of activation (intrinsic activity) that generate coherent and meaningful models of the world. As discussed earlier, a practically infinite number of activation patterns of the thalamocortical system are possible, but only a subset of these would represent meaningful and informative percepts. By controlling the connectivity between the columns, the brain can control the activation patterns that are generated and thus render the model of the world stable, predictable and informative. Without this well-defined connectivity, the activity would become uncontrolled and disordered (a high *entropy* state – note this for later). If we assume the brain is a product of evolution, we can explain the development of thalamocortical connectivity using Edelman's 'Neural Darwinism' (Edelman 1993). As patterns of sensory data are sampled from the environment, they activate specific column populations and the connections between them are strengthened, whilst others may





be weakened. Over time, those patterns of connectivity that are most adaptive to survival (i.e. that generate useful models of the worlds) are selected and the brain gradually develops the ability to generate a stable, predictable and, most importantly, adaptive model of the world (Fig. 3). It is a common misconception that the best phenomenal model of the world is the ‘truest’ one (i.e. the one that most closely matches the external world). However, the brain has no interest in truth *per se* and the best model is simply the most adaptive one. Mark, Marion and Hoffman (2010) used standard tools of evolutionary game theory in a simulated world to test whether *true* perceptions are always the most adaptive. The results show that this is not the case:

Natural selection can send perfectly, or partially, true perceptions to extinction when they compete with perceptions that use niche-specific interfaces which hide the truth in order to better represent utility. Fitness and access to truth are logically distinct properties. More truthful perceptions do not entail greater fitness.

This is an important result, meaning the phenomenal world is a functional model and not necessarily the truest model of the world. It is thus presumptuous to call hallucinations ‘false perceptions’. A better description would be ‘non-adaptive perceptions’, which may or may not be true representations of the world (Hoffman 2011).

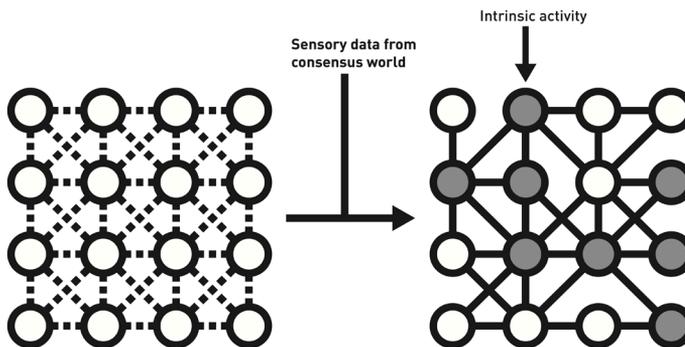


Fig. 3. As sensory data is sampled from the environment, connections between cortical columns are strengthened and weakened. Those connectivity patterns that generate the most adaptive model of the external world are selected. Eventually, the intrinsic activity of the thalamocortical system models the consensus world as a default. (Only strong/characteristic connectons are shown)





This model of neuroevolution can also be explained using information theory. If we imagine an early (and purely hypothetical) brain that hasn't yet evolved to model the external world, this brain will still be spontaneously active and this activity will contain intrinsic information (and perhaps even generate a phenomenal world). This intrinsic self-information can be quantified as the *entropy* of the brain. However, this information tells the brain *nothing* about the environment (external world), which itself contains a quantifiable amount of information (entropy). As the brain evolves by sampling sensory information from the environment and the connectivity of the thalamocortical system is moulded, the spontaneous activity of the brain becomes more and more informative (from an adaptive perspective) about the external world. In information theory this is known as an increase in the *mutual information* between the brain and the environment. The mutual information between two variables (in this case the brain and the environment) is a measure of how much we can learn about one variable by knowing something about the other. This can be represented using a set diagram (Fig. 4); the entire entropy (information content) of the brain is one circle, that of the environment the other. The overlap between the circles is the mutual information between them. As figure 4 shows, the overlap gradually increases with the progression of neuroevolution, as the brain develops the ability to generate an informative and adaptive model of the world. The term entropy is often associated with disorder, but it is actually a measure of the number of possible states of a system. With regards to the brain, we can think of this as the number of possible thalamocortical activation patterns or states. As we have seen, the number of states, whilst theoretically almost infinite, is limited by the connectivity of the system. The brain evolves to *minimise* the overall entropy of the brain, such that the world remains stable and predictable (Friston 2010), whilst concomitantly *maximising* the mutual information between itself and the environment.

We are now in a better position to bring all of these ideas together and formulate a generalised model of phenomenal reality and its relationship to the action of psychedelic drugs, including DMT. We can begin with the idea that the brain is capable of generating a limitless number of thalamocortical activation patterns or thalamocortical states. If all possible states are plotted as points on a 2D plane, the human brain's



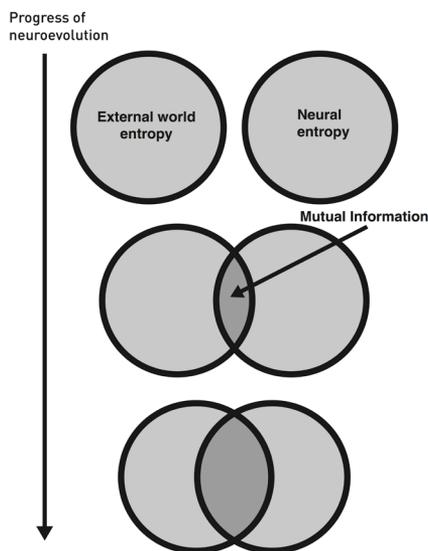


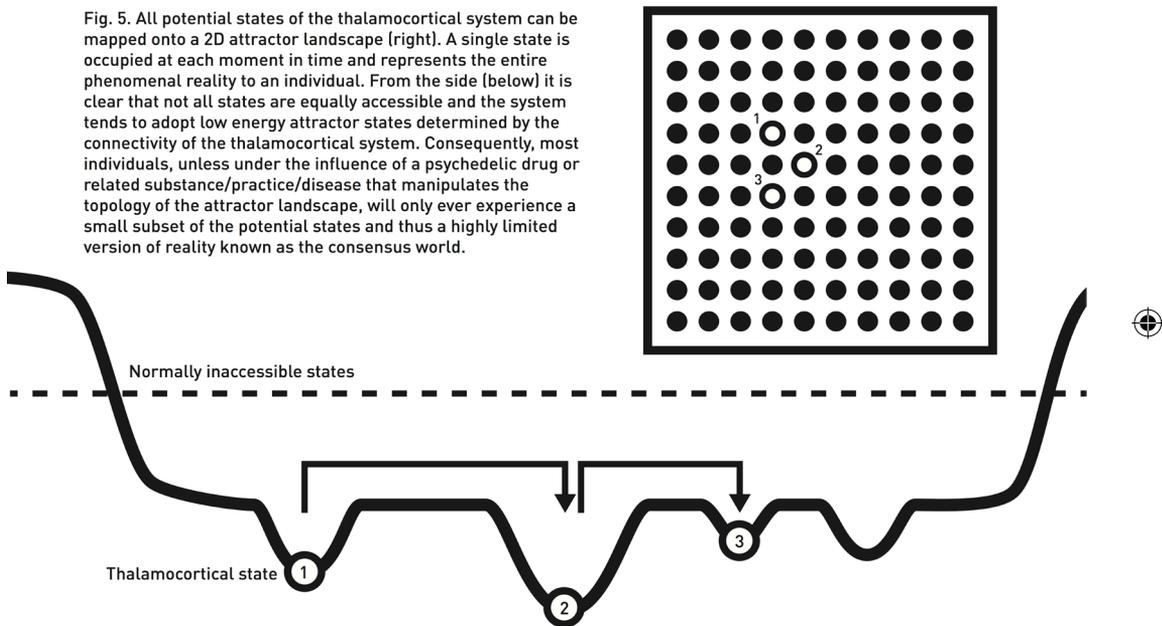
Fig. 4. As the evolution of the brain's ability to build an adaptive model of the environment progresses, the mutual information between them gradually increases.

entire phenomenal reality potential exists on this plane, with each point on the plane representing a single thalamocortical state (Fig. 5). Assuming all phenomenal worlds that can be experienced must have an informational representation in the thalamocortical system, it is not possible for a human to experience a reality that is not represented on this plane. As an individual can only occupy a single thalamocortical state at any moment, each point on the plane actually represents an individual's entire world, or *reality tunnel*, at that particular moment. An individual moves through time by

shifting between thalamocortical states, represented by moving around the plane. Whilst the plane contains an effectively infinite number of points, it is not flat, as all thalamocortical states are not equally accessible. As we have seen, consensus reality is the set of thalamocortical states that have been selected during evolution by the moulding of its connectivity. These accessible states are low-energy states that can be represented by wells and valleys in the reality plane. High-energy states are those that, under normal conditions in healthy individuals, are inaccessible to the thalamocortical system. This reality plane thus begins to resemble an *attractor landscape* (Goekoop & Looijestijn 2011) – the thalamocortical system is pulled towards the low energy states that generate a model of the world that is most adaptive, but this set of states must not be regarded as representing the real world-in-itself. It is merely a subset that happens to possess properties adaptive to the survival of the individual and our species (i.e. represent the most informative and adaptive model of the world). The topology of this attractor landscape is determined by the thalamocortical connectivity of the individual brain and can be regarded as the topology of an individual's reality. This topology will naturally vary between individuals. In most people, the adaptive states are low energy states

and non-adaptive states are inaccessible. However, if the development of an individual's connectivity, and thus the topology of their reality, progresses abnormally, it is easy to see how non-adaptive states may become low-energy attractors. The thalamocortical system would then be able to access these normally energetically forbidden states and this would be experienced as hallucinations and other deviations from consensus reality. Schizophrenia is now described as a 'disorder of connectivity' (Tononi & Edelman 2000) and such reality-distorting conditions may be regarded as a maladaptive reality topology.

Fig. 5. All potential states of the thalamocortical system can be mapped onto a 2D attractor landscape (right). A single state is occupied at each moment in time and represents the entire phenomenal reality to an individual. From the side (below) it is clear that not all states are equally accessible and the system tends to adopt low energy attractor states determined by the connectivity of the thalamocortical system. Consequently, most individuals, unless under the influence of a psychedelic drug or related substance/practice/disease that manipulates the topology of the attractor landscape, will only ever experience a small subset of the potential states and thus a highly limited version of reality known as the consensus world.



Psychedelic drugs, including LSD, psilocybin and DMT, appear to dramatically increase the number of states available to the thalamocortical system. Although the details of how this is achieved are still being studied (Nichols 2004; Carhart-Harris *et al* 2012), these drugs bind to a specific subtype of serotonin receptor, known as the 5HT_{2A} receptor. Whilst the brain's connectivity might be compared to the wiring of an electronic device, it is actually extremely plastic and finely balanced – this enables the connectivity to change throughout

life on timescales from minutes to years. By selectively activating the $5HT_{2A}$ receptor, psychedelic drugs appear to alter the reality topology itself, such that the energetic barriers to normally forbidden and novel states are lowered and can be explored (Fig. 6). Carhart-Harris *et al* (2014) propose that these drugs increase the entropy of the brain, which is equivalent to stating that the number of accessible thalamocortical states is increased, as suggested here. Interestingly, this is an effect that ought to be measurable using modern functional neuroimaging techniques. As the states accessed by the brain during a psychedelic experience are no longer limited to the most adaptive states, there will be a decrease in the mutual information between the brain and the environment. This is illustrated in figure 7 and it is notable that the process appears to be the reverse of the progress of neuroevolution. Carhart-Harris *et al* (2014) suggest that the psychedelic experience is a primitive state of consciousness that preceded the development of normal waking consciousness seen in modern humans and this makes sense from this perspective.

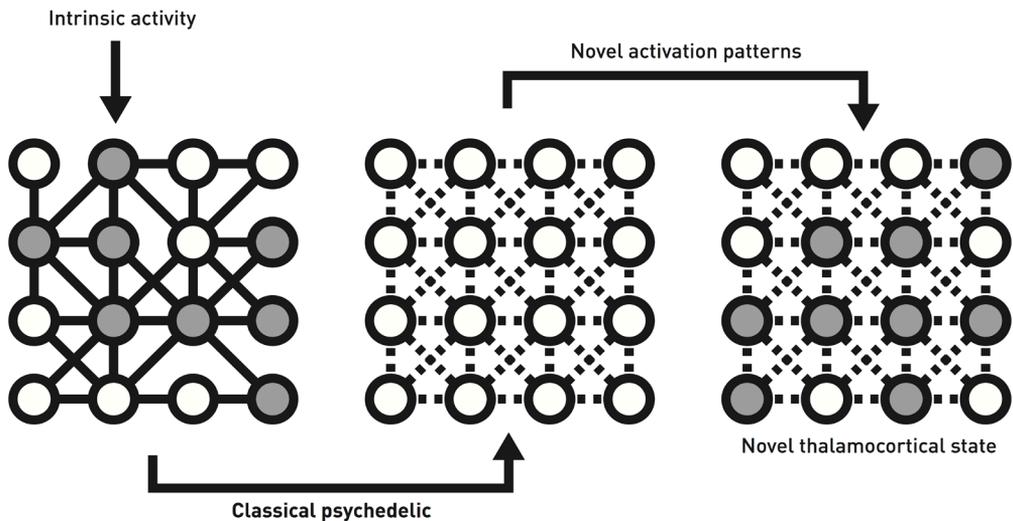


Fig. 6. By activating $5HT_{2A}$ serotonin receptors, classical psychedelics facilitate the adoption of novel activation patterns by the thalamocortical system.



DMT is exceptional in that, given a sufficient dose, the separation of brain and environment becomes complete and their mutual information is reduced to zero. The individual's phenomenal reality is completely replaced by an entirely alien reality that is unrelated to the consensus world. In fact, the brain actually loses its ability to sample data from the consensus world and render a meaningful percept – the user will normally lie back, close his/her eyes and hold tight. It remains a matter of debate as to whether this bizarre world is an autonomous and objective reality (for a full discussion, see Gallimore 2013), but it is difficult to explain why the brain is capable of suddenly generating phenomenal worlds of such beauty and complexity that bear no relationship whatsoever to the consensus world, which, as far as we know, is the only type of world the brain has evolved to model.

Of those that manage to inhale sufficient DMT to 'break through', a significant proportion describe eerily similar types of experience – hypertechnological alien-like worlds, complex machinery, insectoid and mischievous elf-like creatures and other motifs characteristic of the DMT experience (Strassman 2001; Luke 2011). This has convinced many that the DMT reality must have an objective existence. However, such a conclusion raises more questions than it answers. If the DMT world *is* real, how is the brain able to receive, parse and render data from such a reality? Unless the DMT reality is modelled by the brain in an entirely different way to consensus reality, which there is absolutely no evidence for and seems completely unparsimonious, we must assume that it has an informational representation in the brain and is constructed using intrinsic activity of the thalamocortical system. The question is whether this activity is modulated by an extrinsic component, as is the consensus world. It is evident that the drug alters the thalamocortical

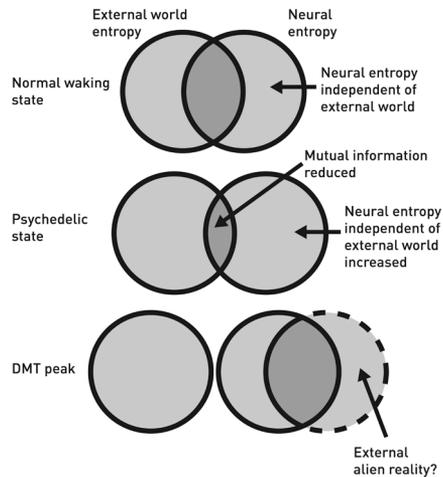


Fig. 7. By increasing the number of available thalamocortical states, psychedelic drugs increase the entropy of the brain independent of the external world, whilst decreasing the mutual information between them. With DMT, the mutual information (between brain and environment) is reduced to zero. It is unknown whether there is a concomitant increase in the mutual information between the brain and an objective alternate reality.





system's intrinsic activity such that the mutual information between the brain and the consensus world is reduced to zero. Does the mutual information between the brain and the DMT reality concomitantly become non-zero (i.e. is there a sensory interaction between them)? There seems no obvious mechanism for the brain to interact with an alternate reality and we must leave this as an open question. However, the DMT experience is a stark demonstration of the brain's ability, under specific conditions, to explore regions of the thalamocortical reality topology that, without DMT, we might not suspect even exist.

As humans, we are equipped with a brain capable of modelling and experiencing a vast multitude of realities. This is not a hypothesis to be tested; it is a fact demonstrable to anyone willing to inhale two or three lungfuls of DMT. Consensus reality is very much a functional reality, a phenomenal reality model that the brain has evolved to facilitate its survival in the noumenal world. It is all too easy to assume that consensus reality is a privileged model of reality, the truest model, *the real thing*. But, as we have seen, it is actually just a tiny subspace within a much broader reality topology available to the brain's extraordinary information-generating machinery and, with the aid of a select number of natural and synthetic psychedelic drugs, this entire topology may become accessible and open to exploration.

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