8 The Most Complex Object in the Known Universe

The human brain contains eighty-five billionor so neurons, each of which are directly linked with thousands of connections to other neurons. A ‘brain state’ is defined as the snapshot of the brain’s *configuration* at any given time. Configuration in this sense is defined as the three-dimensional map in which neurons happen to be firing at a given instant and of which inter-neuronal connections and axons are either active or idle at that time.

Collaborative neuron ensembles, once established, enable the brain’s owner to acquire specialized skills which can then be summoned up without deliberate thought (whence the expression ‘*I could do that in my sleep*’) and to store memories. Practice and habits are the traditional way whereby resonant ensembles of neurons are progressively established within the brain.

The number of possible brain states is gigantic: it is estimated at about 2 to the power 85 billion configurations, a straightforward calculation if we model the brain as having 85 billion neurons, each of which capable of being in either one of two possible states (i.e., active or idle).

The time it takes for two neurons to communicate (in other words for data transfer between neurons to occur), and for an individual neuron to shift from active to idle status or reversely, is about one hundredth of a second. since it is estimated that between one and ten percent of total brain capacity is used at any instant of time, up to ten percent of the brain can change its status every hundredth of a second. On the basis of these and other considerations (such as thermodynamics within the brain), it is estimated that the maximum number of different brain states that can arise per second is roughly equal to ten to the power twenty (10ˆ20) per second. A human being is thus not equipped, and hence unable to perceive, any event or occurrence of any kind that would happen faster than 10 to the power minus twenty seconds (in reality our scale of perception is much coarser, because billions of neurons need to be collectively involved for a conscious perception to register.) In other words, we live within our own discrete time, although we are unaware of it, with a small but incompressible biological quantum of time equal to about ten to the power minus twenty seconds. If a physical quantum of time exists and is shorter than that limit, we just cannot perceive it and will perceive time as continuous. As we’ll see, various calculations of an upper limit for a physical quantum of time in our universe yield values which are, as it happens, far smaller than this biological limit.

Because of quantum effects in the brain, there is a far greater number of ways by which different neurons can communicate with one another, and immensely many more resonant ‘collaborative ensembles’ of neurons can be established than would be the case if the brain were a mere (non-quantum mechanical) chemical machine. Many authors have argued that the brain is the ultimate quantum information-processing machine (37). The essence of how quantum effects can enhance the way information is exchanged in the brain lies in the way synapses “fire”; the mediators of information exchange are particles (ions) and therefore they are, first and foremost, *wave functions* rather than material particles. Owing to quantum effects, the "firing" of a donor neuron does not necessarily occur towards the immediately facing receptor synapse but may involve any other synapse located anywhere within the brain (i.e. not directly facing the donor synapse) and can simultaneously involve any ad hoc group of synapses, which leads to an immense number of possible firing configurations. Being essentially wave functions, the brain's data-mediating ions are able to link up and communicate with any synapse and establish collaborative resonance patterns with any group of neurons anywhere within the brain. This quantum trick immensely multiplies the number of possible 'brain states' – and hence the brain's data-processing power.

A number of different mechanisms have been put forward to describe the manner of neuron interactions at the quantum level – the bottom line being that such effects would work mainly through the existence of chemical exchange processes within the brain involving spread out wave functions; because wave functions associated with data exchange can, and do spread out, communications between ions do not always necessarily involve the immediately facing synapse when a neuron fires. Ultimately, any synapse anywhere in the brain can participate in any data exchange, thus multiplying the number of receptors able to become involved in any particular communication originating from any given neuron.

Some other researchers, such as Victor Stenger, do not believe that such quantum effects occur. The gist of their argument is that the timescales of events within the brain are sluggish in comparison with those involved in quantum effects and that action distances in the brain are longer than the usual distances over which quantum processes take place (this latter objection can, thanks to Bell's theorem, be safely ignored.) There are, generally speaking, many 'quantum effects' in biology which we once did not think possible and are just only beginning to discover. Photosynthesis for instance essentially depends on quantum effects, whereby the most efficient itineraries for ion exchange are ascertained quantum mechanically. Or, Luca Turin published a 2011 paper convincingly showing that the astonishing human ability to smell a *trillion* separate odors, or so, stems from quantum processes in the nose - an ability which could otherwise never arise from the lone means of the 450-odd separately specialized chemical receptors we have in our noses. Such processes do not operate by absolute thresholds but involve probabilities of occurrence and involve odd quantum effects such as tunneling, whereby an effect can happen even if the energy necessary for it to happen is not there. Whenever the relevant numbers involved are huge (such as the number of neurons that may participate in a thought, or, say, the number of atoms in a tunnel diode or a field-effect transistor, or the number of participants in a Lotto draw), rare outlier events at the extremes of statistical probability become routine. As mentioned earlier, experimental traces of quantum effects in the brain (such as the observer-generated so-called quantum Zeno effects) have been ascertained. If the brain followed strictly classical chemical and biochemical laws, any donor neuron synapse could fire and exchange a chemical carrier of information (an ion) only towards the synapse immediately facing it. Were it not for quantum physics, it is quite possible that our data and thought-processing power would be more limited, and that we'd be less intellectually nimble than we actually are.

A brain's, or to put it in a more holistic but roughly equivalent way, a *person's* wave function describes and governs the way a person interacts with their environment. Associations with other wave functions from the environment are established, evolve, and then may dissolve (*decohere*) in an ever-shifting dancing landscape of wave functions.

Somewhat frighteningly, a person's wave function can itself decohere and split into independent sub-wave functions. These *sub*-wave functions can remain loosely associated with a 'parent' wave function, or between one another, or alternatively become wholly independent - *decohered* - from one another.

Simple deliberate volition can cause 'internal brain decoherence' to take place, and, as the psychiatrist Dr. Mark Salter of the Homerton Hospital in London once put it, "it is scary".

This following conversation with Mark Salter is cited by William Storr who was interviewing Dr. Salter in the context of people who seemed to change personalities when performing on stage:

> *Dr Salter*: Call it Multiple Personality. We can all have them
>
> *William Storr*: I don't have multiple personalities
>
> *Dr Salter*: Well, try a little trick for me:
>
> Just imagine a version A and a version B of yourself and have a conversation in your head between them as you drive home from this interview. You know, like,
>
> "*What are you doing tonight?*
>
> Well, I thought I'd write up this interview
>
> *Well you could, but there's some great TV on*
>
> I know, but I have a lot of backlog work to deal with ..."
>
> Carry on like that for one hour and I promise you, *you'll scare yourself*. Before long, the first voice will become, say, more outgoing and develop a liking for art and German techno music; the second one will be introverted and prefer science and South American heavy metal.....

Most often though, and very sadly, split personalities are precipitated by traumatic events as the brain seems to try to protect its owner by *decohering* and thereby sheltering them from the bad experiences that sprung from the outside environment – by establishing new wave functions untainted by bad memories and links with other wave functions and realities (38).

We will encounter below much odder, and as yet not fully explained, ways in which the brain deals with time (specifically, by processing so-called *saccades*.) But before we can return to time, we must look at another essential feature of reality: the so-called uncertainty principle, *aka* the Heisenberg principle.