Remote Learning Module for 27 April 2020

Lecture Notes on *The Cerebral Code* – Chapters 7 - 9

Last class we considered how the phenomenon of harmonic resonance can serve to explain the transition from active spatiotemporal patterns to spatial only storage in cerebral cortex, and we sketched out neural analogs to some of the catalysts that serve to enhance and accelerate biological evolution in natural environments. Today, after our Intermission, we turn our attention to the mechanisms Calvin proposes for modeling the brains of what Dan Dennett called Gregorian Creatures: human beings, and our capacities for abstract thinking and language acquisition.

* * *

— Chapter 7 —

Brownian Motion

(1) We begin with a classic problem in the philosophy of mind—a problem as old as the one Plato thought his Archetypical Forms would solve, and one that fueled much debate during the modern period: how, from our sensory acquaintance with particular objects are we able to form abstract concepts so general that they have no sensory equivalents whatsoever. For our primary example, we consider the idea of *triangularity*. The problem is easy enough to grasp when you realize that every possible triangle you can imagine will be either scalene, isosceles, or equilateral, while your concept of triangularity is simply that of any plane geometrical figure formed by the intersection of three nonparallel straight lines. Recall that Alain Connes' insistent commitment to Platonic Realism in *Mind, Matter, and Mathematics*, was driven by his supposition that nothing short of our acquaintance with an "archaic mathematical reality" could possibly explain how we are able to fashion ideas like *triangularity* in the first place, much less prove things true of this general thing.

(2) For his empirical model, however, Calvin adopts the notion of *radial concepts* that we saw in Hacking's book, *Rewriting the Soul*. By adding a dash of David Hume's Principles of Association (which we saw in Dennett's account of Skinnerian Creatures), Calvin supposes that from our encounters with individual things, we move to clusters, to prototypes, to paradigms, and ultimately to categories by way of associations. This series is quite reminiscent of Aristotle's efforts to naturalize Plato's forms, if anyone's keeping score. Aristotle, of course, did not have the benefit of Darwin's evolutionary account of speciation from which to draw analogies. We do, so let us return to Calvin's thread. If our brains are indeed Darwin Engines, then we should be looking for the manner in which the Hexagon Theory can generate this series of associational products. Calvin supposes that all we'll need is a recursion tree, whereby the same kind of associations are reproduced first in clusters, then in concatenations of clusters, and finally in composites of concatenations.

(3) The key to this process is an analog to Brownian Motion in physics: random collisions (connections) build up via chaotic attractors. Thus, patterns within patterns yield syntax, and relations among relations yield metaphor: these are the very abstracta for which we are looking. Ghostly attractors play a key role in the generation of novelty (which Calvin likens to jazz improvisation). With such attractors, we find chaotic itinerancy: a pattern meandering around the attractor landscape (or mindscape, if you will). Just this sort of mechanism is sufficient to produce the chain of associations from individuals to categories, via the neural implementation of a *distributed database*. Thus, the hard problems surrounding the production of category formation are shunted off to the prototype, where fuzzy boundaries are maintained around attractors.

* * *

— Chapter 8 —

Convergence Zones

(1) We last encountered the neurophysiology of convergence zones in Damasio's Somatic Marker Hypothesis. Here we find Calvin appealing to the same notion under a new metaphor for the distributed database he supposes provides the recursion tree necessary for category formation. Calvin's model is based on variables whose values are measures of signal travel-time. Damasio's convergence zones become telephone switchboxes on this metaphor: a long distance operator acts as a central funnel for conference calls; today, of course, we might prefer to think of video conferences. Such conferences, like our webinars, are shunted across the Internet in packets, leaving our browsers to do most of the work locally. On this analogy, the neurophysiological patterns we are looking for will be equivalents for (a) talking to neighbors, (b) making local calls, and (c) long distance calls. The Hexagon Theory provides all three. Via axon projections to distant sites, where we have a point-to-point connection, plus an annular ring projection, we find a mechanism for cloning in distant cortex.

(2) This model also predicts some forms of psychological dysfunction. In cases were people have trouble forming abstract ideas (like triangularity), we can expect to find what Calvin calls "premature closure" of association pathways, linked by cortico-cortical connections. Reaching a decision, that is, without consulting linked attractors stored elsewhere inhibits seeing analogies, and accounts for phenomena like dissociation and agnosia.

* * *

— Chapter 9 —

Chimes on the Quarter Hour

(1) Still working on the problem of memory, in this chapter Calvin adopts the model of hardwiring by way of software *scripts* in information technology. A good example of how scripts work can be found in the computer code for word processing that will complete words,

and in some cases, whole phrases, for us as we type or touch a few initial letters (sometimes leading us unintentionally to say rather embarrassing things when we fail to proofread our email and text messages). We can also think of a script as the software version of a *finite state machine,* like a coke dispenser, or a ticket machine, or an automated bank teller. The plot-lines of most soap operas, situation comedies, and mystery stories are also good examples of how scripts work: think of how you can anticipate the usual obligatory chase-scene roughly five minutes before the climax in a crime thriller film. Scripts, in other words, are bits of narrative that endow Dennett's Popperian Creatures with the ability to *anticipate experience* before acting. Calvin thinks we can account for the character of dreaming on this model as well. (Recall his opening quotation from Carl Jung.) In dreams, Calvin thinks, we run familiar scripts, but juxtapose all manner of itinerants into the story.

(2) Returning to convergence zones and their explanation in terms of signal timing, Calvin directs our attention to the neurophysiology behind our ability to hurl ballistic objects, like baseballs. He knows a lot about this from his empirical work in the late 1970s (see his *The Throwing Madonna*, for example). When we toss a ball at a target with precision, our motor strip has to set up a sequence of signals to control an extended series of muscle fibers. The requisite launch window for such sequences provides the key: each muscle fiber must be activated at just the right moment in the sequence in order for our arms to produce the smooth concatenation of forces needed for hurling projectiles. Now, the normal jitter (random firing) of motor neurons is about eleven milliseconds. Yet, when we throw baseballs, we best this by an order of magnitude. The question is: How? Calvin's answer is: memory. You activate similar "muscle memory" when typing rapidly and accurately; musicians often call the same ability, "finger memory."

(3) Precise measurement reveals that in order to sequence a chain of muscle responses, the signals from motor strip must override the normal jitter intervals among nerve firings: it turns out to be an inverse square rule such that in order to reduce an interval of jitter requires four times the number of cells responsible for coordinating the signal. Thus the combination of cloning operations, and the exact time it takes for these operations to occur in sequence, provides the fabric we need for making sense of memory as the activation of a distributed database.

(4) Calvin concludes this chapter with a sentential example. Consider the word, "give." For a sentence in which "give" appears as the transitive verb, we can anticipate, thanks to a script (physiologically, four basins of attraction), that such a sentence will specify who gives what to whom; and we'll not have a sentence (a complete thought) until the activation of the word, "give," finds suitable activations of words for who, what, and to whom.

* * *

Next time, we'll look to Chapters 10 & 11 of *The Cerebral Code*, where we'll encounter Calvin's account of how we generate metaphors and accomplish the tasks of high-level intellection: thinking a thought in the mosaics of the mind. Be well everyone, and, as we continue our undoubtedly strenuous efforts in the exercise of social distancing, let's take time again listen to music.