Remote Learning Module for 17 April 2020

Lecture Notes on *Mind, Matter, and Mathematics* – Chapter 7 & Epilogue

Last class we examined three species of "thinking machines": our own brains, neural networks, and computer programs. We wondered in each case whether, and if so to what degree, mechanical intelligence might help us unravel the knotted sources of disagreement between physicalism and dualism as regards the nature of mathematical objects and the sources of mathematical truths. We concluded our investigations with a promissory note linking good, old-fashioned Artificial Intelligence with Connectionism (neuromimetics): if we're ever to construct machines that can reasonably be said to resemble ourselves (short of biological reproduction), such machines will need be self-evaluating systems capable of suffering. Today, we'll follow the last exchanges between Changeux and Connes, as they endeavor to reach some sort of rapprochement; and we'll consider, in the Epilogue, the prospect for building a naturalistic ethics based entirely on the life and social sciences.

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— The Real and the Rational —

(1) The Nature of Mathematical Objects Redux.

The chapter opens with Poincaré's portrait of mathematics as the creation of abstract objects by way of construction and analysis. Connes is prepared to accept this characterization, but suggests that they leave questions of existence to one side, and focus on the business of analysis. In turn, he offers a distinction between the methods of classifying mathematical objects by way of *inductive* systems, on the one hand, and *projective* systems, on the other hand. Inductive systems proceed by way of exhaustive search, item by item, while projective systems work by providing recipes for including or excluding candidates from a given set. Logically speaking, what he's getting at here is the difference between the two meanings of "meaning": extension and intension. The *extension* of a term is the set of objects to which the term refers. For example, the extension of the term, "coronavirus," is the sum total of all the instances of these protein-coated replicators, past, present, and (hopefully not many) to come. The intension of this term would be provided by the tests for their presence or absence—of which we don't yet have enough (the tests, that is—the criteria by which we delimit the extension of the classification).

What emerges from Connes distinction, however, is rather a bid for classical Platonism: inductive labeling (specifying an extension by exhaustive search) treats each individual as a *singular* object, that is, a token; projective labeling defines a type: a projective label names a *general* thing.

Changeux, however, uses this very distinction to argue that since mathematical objects are indisputably mental representations generated in brains, they are, therefore, *singular physical*

objects, and so, part of the physical world, not elements in an "archaic" mathematical, Platonic world. Unpacking this assertion, Changeux goes on to assert that our brains project all right, but what they project are representations onto the world. Each mathematical object is a singular physical object build up within the brain, with well-defined spatio-temporal properties (dynamical physical states of neuronal networks), and invariant patterns among these states are what we call "representations." Such objects: (a) have causal power (to carry out mental operations and to signify values); (b) are universal in all human communities; (c) have formal content, which can be discovered gradually over time; and (d) are capable of producing new objects, and are therefore generative. As we have surely come to expect, Connes resists this nominalist reduction.

(2) The Construction of Mathematics by the Child.

Turning then from their metaphysical dispute (which remains unresolved), the pair ask: How is mathematical ability acquired? They agree that we begin with numbers, noting that infants (and even many mammals) can distinguish two taps from three taps sounding in their environments, so they are capable of discriminating discrete quantities. Mathematical understanding then proceeds from learning cardinality (1, 2, 3, …) to learning the ordinal numbers (1^{st}, 2^{nd}, 3^{rd}, …). With these in place, we use language to create recursive rules, and eventually invent/discover the set of integers. Changeux says it is tempting think that imposing categories on the world is a technique for exploring the world; but we must remember that all this is a matter of social conditioning.

(3) Order in the World.

Puzzle: How can one physical state (internal) *represent* another physical state (external)? The answer, they agree, must have something to do with isomorphism, as in the topological isomorphism that can be detected in monkey brains between visual objects and activation patterns in the primary and association visual cortices. Perhaps it is from such an isomorphism that abstraction emerges, and by a cascade of higher orders of abstraction, arithmetic emerges—as a *product* of abstraction, not as a functional result of brain structures.

At this point they wonder if the logic of this cascade might be an instance of what Penrose and Hawking called the *Cosmological-Anthropic Principle.* This notion says that we're here today because of all the possible worlds that might have been, only one like this would end up producing beings like us. Changeux reads this as a teleological magic trick, but the question is vexed by its having two different interpretations: (a) Why is the universe as it is rather than some other way it might have been? and (b) Why do we find ourselves in this universe and not in some other? The "anthropic principle" may prove mythological for answering (a), but may prove satisfying for answering (b). In any case, they agree to Spinoza's rejection of teleological causes: nature has no end in view, no "meaning."

(4) Summations.

The main dialogue ends with each interlocutor summing up his position.

Changeux: "The regularities in the physical world might not be anything more than the product of the history of the universe, of an evolution that is still unfolding." He cites here a provocative assertion by Max Delbrück, in *Mind from Matter*: the formation of the elements (which ones happen when) depends on variation and selection among elementary particle configurations—survival in the literal sense: only some of the possibilities have become actual.

Connes: External reality is a *struggle* between the loss of information due to friction with the external world (the *continuous* physical world), on the one hand, and on the other hand, the biological phenomenon constituted by the duplication of *discrete* information in the process of genetic transmission. In the course of further articulating this claim, Connes returns to his Pythagorean ontological commitments: external reality is a part of archaic mathematical reality. Physical objects, on this view, behave according to the laws of geometry and the laws of physics of the continuum; biological objects develop according to iterative processes over discrete bits of information (the laws of arithmetic). Insofar as external reality is a struggle or tension between the two, we are left with the oldest of Pythagorean conundrums: Incommensurability.

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— Epilogue: Ethical Questions —

(1) Besides a brief excursion into the ethical implications of modern cryptography from Connes, this section is dominated by Changeux, who places himself in league with Spinoza, Darwin, and Peter Kropotkin. In this, he proposes a "rational theory of good and evil," that is, an ethics based on science, not only of neuroscience and evolutionary biology, but anthropology, cognitive science, and history.

(2) Not Religion. His first target, however, is religion. Echoing Spinoza, he holds that morality is simply a biological phenomenon, and the central problem for understanding this phenomenon is to accommodate both (a) the universality of moral instincts and judgments across cultures, and (b) the relativity of moral norms to time and place.

(3) Universality. Changeux thinks that the frontal lobe configurations we have uncovered by way of neurobiology and neuropsychology are what account for the universality of ethical behavior in the human species. He's thinking here about exactly the sort of configurations we encountered in Damasio's somatic marker hypothesis and Poppers's account of our ability to experience other people's intentions vicariously by way of hypothesis. Children, he notes, spontaneously express prosocial behavior (sharing treasured objects in order to initiate conversation and communication). The central argument here echoes not only Damasio, but the ancient thought of Aristotle and Confucius: our genetic predispositions are refined by social contexts, like sharing, to generate emotions of *sympathy*.

(4) Not Sociobiology. Sociobiology (the term coined by E. O. Wilson) sees social institutions as expressing the strategies of genetic transmission. Wilson was, we might note, an entomologist, with his primary work in myrmecology (ants). But, as Changeux complains, metaphors and analogies between human societies and ant colonies have many pitfalls. There is no reason whatsoever, he contends, to suppose that in present day societies there is a relation between the

moral rules peculiar to a given culture and a Darwinian propensity for transmitting the genes that produce such rules. Rather, ethics abbreviates the logic of sympathy into rights, duties, and habits, thus producing ready-made responses to future behavior. Rather than Sociobiology, the right evolutionary model to employ is the evolution of knowledge—because knowledge is a social product, just like ethics. Moreover, this model provides for novelty: the liberation of new forms of behavior. And this feature is what, on Changeux's view, implies that ethics could fall under the primary rubric of science: ferret out the irrational by way of theoretical models and empirical test.

(5) The Logic of Good and Evil. Turning to Darwin, Kropotkin, and Hobbes, Changeux concludes his analysis with the speculation that the right sort of model for ethics should be one that provides a logic of good and evil where things that enlarge sympathy and facilitate mutual aid are good; and things that hinder these are evil. If so, then our reflective equilibria should select those actions that promote sympathy and mutual aid. Let's think about this in the context of our current public health crisis.

(6) Adopting this logic of good and evil can be expected, Changeux predicts, to lead to an evolutionary secularization of morality, where there must be space for variability and, hence, randomness. We should demand among our human rights, the *right to difference*. The three main elements in this sort of naturalistic ethics are: (a) a rational critique of beliefs and ideologies; (b) the enlargement of sympathy and mutual aid; and (c) the right to difference and imagination to express the uniqueness of each individual person.

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Next time, we'll look to William Calvin's *Cerebral Code*, where we'll encounter the Darwinian schema once again, with a sustained emphasis on the claim that our brains are, quite simply, "Darwin Engines." Be well everyone, and, although I imagine you are probably quite tired by now of my continuing to say so, do remember: social distancing continues to save lives, which is presumably why we are still not in JUB 202 presently.