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Neuroscience and the correct level of explanation for understanding mind

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Abstract

An extraterrestrial roams through some neuroscience labs and concludes earthlings are not grasping how best to understand the mind/brain interface

An extraterrestrial lands on Earth and, naturally enough, wants to know what makes humans tick. ET wonders whether humans might know themselves, so he (it?) visits labs—the very best neuroscience labs. There ET sees people sticking electrodes into single neurons within multibillion neuron brains in the hope they can decode how thoughts and emotions are realized. He notices others measuring how blood goes here and there in the brains of people playing computer games in large noisy magnets. Still others are looking at how the expression of thousands of genes might give clues to which structures are involved in particular behaviors. ET is utterly mystified. Humans seem enthralled with measurement of underlying parts but don't realize that they have lost the plot—the understanding of mind.

Luckily ET discovers that an earthling philosopher, John Stuart Mill, thought about this problem 150 years ago:

All organized bodies are composed of parts, similar to those composing inorganic nature, and which have even themselves existed in an inorganic state; but the phenomena of life, which result from the juxtaposition of those parts in a certain manner, bear no analogy to any of the effects which would be produced by the action of the component substances considered as mere physical agents. To whatever degree we might imagine our knowledge of the properties of the several ingredients of a living body to be extended and perfected, it is certain that no mere summing up of the separate actions of those elements will ever amount to the action of the living body itself. ([1], Bk.III, Ch.6, §1).

Later some British philosophers labeled this and related ideas “emergence”. C. D. Broad eventually formulated what amounts to an “emergent law” and tells us that it “would be a statement of the irreducible fact that an aggregate composed of aggregates of the next lower order in such and such proportions and arrangements has such and such characteristic and non-deducible properties.” [2, p. 78]

Unfortunately, ET discovered that neuroscientists dislike this kind of thinking. They cling to the idea that understanding the elementary parts of the nervous system will explain how the

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brain does its magic to produce the psychological states we all enjoy. Letting go of this idea seems dangerous to most of them, who fear that some kind of ghost will be snuck into the brain. This fear struck ET as strange, since other scientists working on other complex issues have no problem with the idea of emergence. Physicists, chemists, and biologists all know about it. In the context of physics, for example, Philip Anderson notes, “The ability to reduce everything to simple fundamental laws does not imply the ability to start from those laws and reconstruct the universe. In fact, the more the elementary particle physicists tell us about the nature of the fundamental laws, the less relevance they seem to have to the very real problems of the rest of science, much less to those of society.” [3, p. 393]

So how does the brain do it? Understanding how each and every neuron functions still tells one absolutely nothing about how the brain manufactures a mental state. Sure, they all conduct electrical impulses and secrete neurotransmitters in the service of communication. But how does this produce thoughts and feelings? And how can this system keep ticking after the interacting neurons are disrupted by structural or metabolic lesions? Just as a social democracy continues to work when individuals who make it up are eliminated, so too does this biologic network. It is as if the emergent function guides the underlying physics.

This is a familiar problem, thought ET. The trick for any level of analysis is to find the effective variables that contain all the information from below that are required to generate all the behavior of interest above. ET knew this was as much an art as a science.

Nonetheless, there are explicit ways to think about emergence and how it constrains the units that generate it. The general idea has been discussed by David Krakauer and colleagues [4]. In brief, the idea is that bottom up causality which is to say going from a microscopic level such as atoms or cells, to a macroscopic level such as thoughts and feelings, can almost seem incomprehensible. Similarly top down causality refers to when such macroscopic states as feeling “pity” may impact the microscopic level.

This sort of reality—the macroscopic level impacting the microscopic level—is all around us. Our everyday use of computers as when word processing or doing spreadsheets finds us using a macroscopic level of programming which in turns controls the micro-structure of the computer. The emergent phenomenon is controlling the elements that generated and built it! And so too for the brain. We only have access to our emergent properties, such as anger and perspective and the multitude of other mental variables, not the micro-elements that produced them. We have to work at the macro-level of emerged phenomenon. We are in no way separate from the machine but are only able to understand ourselves at the macro-level.

All of this gave ET pause. On the one hand Krakauer and colleagues capture the facts of the physical world and causality, while on the other hand they recognize emergence. Indeed, without these higher emergent levels existing, there would be no possibility of communication, as every particle we wish to move in an utterance would have to be known, rather than have the mind-compiler do the work.

ET wondered why neuroscientists were so adamant about their view on the nature of their existence. They remained constructionist, maintaining that by understanding the parts, they will understand the whole. They have spent billions trying to understand simple organisms like worms and flies and lobsters. They are even seeking help from electrical engineers, who can tell you how a thing works if they see the diagram. They cannot tell you, of course, about the content of the information being processed, but they can tell you about the operation of the thing.

Cleverly, ingenious scientists are drawing out the maps of simple systems and studying all the parts. No one does it better and with more awareness than Eve Marder when she examines

lobster gut motility. She has every neuron/synapse worked out and models the synapse dynamics to the level of neurotransmitter effects. Her laboratory did a brute force calculation of all possible parameter combinations in this model, which turned out to be millions of combinations [5]. By modeling all those combinations, it turned out that about 1–2% could lead to appropriate dynamics that would create a motility pattern observed in nature. This still turns out to be 100–200,000 tunings! And this is what they see in recordings. So there is enormous diversity of functional states at a local level, leading to a common behavioral phenotype. That is in a lobster. How on earth will neuroscientists ever figure it out in humans?

ET smiles. It sounds so difficult and puzzling and impenetrable but he knows the problems will be solved. For some who have thought long and hard about the issue, the puzzle remains. The philosopher Jaegwon Kim [6] has grappled with how one gets mind with all of its qualia out of brains and concludes that brain mechanisms take you almost all the way but stop short of being able to explain sensations in the mind.

Is that where the problem will rest? ET wondered. Yes, there is emergence but, just as there are Newtonian laws that reflect the underlying quantum laws, so there should be laws of mind that reflect the underlying neuronal principles. Sebastian Seung, a computational neuroscientist, discusses at length the differences between folk psychology and what he calls atomic psychology. As he reports in his forthcoming book (Seung, S. <http://hebb.mit.edu/~seung/brainforest.html>), put a cookie in front of a hungry young boy and folk psychology—the psychology of everyday life—will predict with near 100 percent accuracy what will happen next. For atomic psychology—the molecular science of mind—to make a prediction, it would have to know all initial conditions of every atom in the young man's brain and possess a computational device of enormous magnitude to make its perfect prediction. That is a preposterous goal.

There seems to be a change in the air, ET thought. The world's leading neuroscientists are beginning to accept emergence. For example, William T. Newsome, believes in emergence and ultimately in the idea of downward causation. He wants to know where does one stick the electrode to study it with scientific rigor [7]. He does not believe the single electrode approach will work and instead believes downward causation will have the form of a higher “state” of the nervous system governing the action of single units and smaller circuits within the brain [7].

ET's spaceship was waiting for him. As he boarded the craft, he mused that the report to home base would be easy. “The earthlings are stuck in a quagmire. They don't see that brains are decision making devices and should be understood in those terms—that level of description, not lower. They are only partially evolved. It will be eons before they ever find us. It might also be eons before they ever understand themselves.”

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