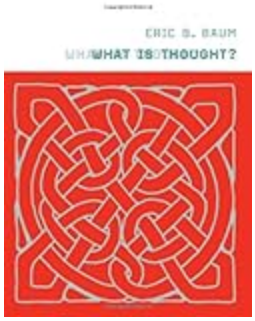
What Is Thought?



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Reviewer: Aarre Laakso, Ph.D.

Baum is a well-known computer scientist, highly and deservedly respected for his early work on neural networks and, more recently, genetic algorithms and evolutionary programming–intriguing but rather narrow technical topics in computer science. *What is Thought?* is a broad-reaching book that concerns how meaning, understanding and thought could arise from the operation of a machine like a computer or a human body. The book's thesis is that thought is the execution of a computer program encoded in the DNA, that understanding is a consequence of the compact structure of this program (which was achieved by evolution), and that this program (and the thinking that it gives rise to) is meaningful because it captures the underlying structure of the world.

The book provides relatively accessible introductions to many important topics in computer science, mathematics, molecular biology and other disciplines, including: gene transcription and expression, neural networks, Bayesian statistics, information and communication theory, genetic algorithms, learning theory, algorithmic complexity, and even metaphor. It explains many highly technical concepts, including Turing machines, the Vapnik-Chervonenkis dimension, Kholmogorov complexity, Bayes' law, the Traveling Salesman Problem, and the class of NP-complete problems in general. Anyone who has heard these terms but doesn't know what they mean would

benefit from reading the relevant sections of this book. The technical explanations are by and large clear, if sometimes incomplete. Nevertheless, each explanation includes citations to the original literature on the topic, allowing the reader who is sufficiently interested and motivated to follow up on any topic. Many of the explanations assume some mathematical sophistication (at least logarithms, summation notation, Boolean logic, and set theory). The sorts of topics that *What is Thought?* addresses are similar to those in Douglas Hofstadter's books, especially *GÃ¶del, Escher, Bach,* although this book does not have quite the same flair as that one.

One of the central claims of this book–that meaning comes from compression–is counter-intuitive. The book claims that "If one compresses enough data into a small representation, the representation captures…real meaning about the world" (102). But think about the program WinZip, which compresses files on personal computers into smaller packages that can be downloaded from websites or sent via email. Many people are familiar with "Zip files," but nobody thinks that WinZip has captured any real meaning about even the files on which it operates, let alone about the world at large. Baum would presumably argue that this program does not compress a wide enough spectrum of information into a small enough representation. But what reason is there to think that a "SuperWinZip" program that compressed more things better than regular WinZip would achieve understanding? *What is Thought?* does not offer an answer.

What is Thought? frequently uses anthropomorphic, teleological and intentional language to describe evolution: "the DNA discovered how to build multicelled creatures" (311), "evolution cannot find a use for computing an intermediate result until it knows how to use it, and it can't figure out how to use it until it knows how to compute it" (323), "evolution has learned to learn" (323), and "what evolution did … was to *design* the language" (340, emphasis in the original). I assume that these claims are only offered as a manner of speaking, that Baum does not seriously believe that DNA can discover things, or that evolution can learn or design, strictly speaking.

The book also makes very strong innateness claims. For example, Baum writes, "following the consensus view of the linguistics community, I argue that we are specifically evolved to learn language" (306). This view is emphatically not the consensus view of the linguistics community, as a glance at a book on cognitive or functional linguistics will verify–Michael Tomasello's *Constructing a Language* is a good, fairly accessible example. According to *What is Thought?*, not

only language and vision, but also social interaction, reasoning, and faculties for understanding Euclidean space and causality, among other things, are innate. Indeed, the book claims, "much of human concept structure is biased in" (329). However, it is not clear exactly what it means mean for something to be "innate." Throughout *What is Thought?*, one gets the impression that just about anything can be "coded into," "programmed in," "wired into" or "built in to" the genome, and this notion of coding seems to amount to a kind of physical containment. Indeed, the book even contains passages about "putting" and "pushing" knowledge into the genome (e.g., "it is not always fitter to put knowledge into the genome" and "knowledge pushed into the genome is there from birth" (333)). The same may be said about the concept of a "bias." *What is Thought?* makes a good case that some sort of inductive bias is necessary to get learning started in any sort of system, be it human or computer. Rather than viewing such biases merely as dispositions to behave (or change one's behavior) in certain ways, however, the book asserts that they are "in" the learner. Thus, we find statements like "much learning in animals and presumably in people as well, including language learning, is not general-purpose but specifically biased in" (328). One wants to know: what exactly is "biased in" to what, and what does this mean? For example, when we read that "animal learning is, to a point, highly biased in, providing evidence for the innateness of much learning" (347), are we supposed to conclude that "learning" is somehow "in" the animal or "in" its DNA? If so, what is the meaning of that claim? (Could we identify the location where the learning is, for example by putting our finger on it?) If not, then why not merely say that learning is biased instead of "biased in"?

What is Thought? argues that the mind should be modular because modularity is good engineering practice (215). This is a surprising argument in a book that is at pains elsewhere to point out that engineering is not always the best way to solve a problem. Furthermore, the concept of a "module" remains unanalyzed, although the book sometimes suggests that modules are physiologically discrete brain structures: "it seems plausible that the modules would be associated with different small regions of the brain, each predisposed to learn or code different concepts" (329). This is an unusual view–even those who agree that mind is modular usually argue that the modularity is functional, not physiological.

It is nice to see someone from another discipline taking philosophical issues seriously, and Baum has clearly taken the time to read a substantial portion of the philosophical literature that is

relevant to his topic. However, the book contains some philosophical mistakes. For instance, it asserts that *cup* is a natural kind (288). In fact, *cup* is often used in philosophical discourse as an example of just the sort of thing that is *not* a natural kind, that is, not the sort of thing that enters into the laws of science.

What is Thought? grapples seriously with hard issues about consciousness. To some extent, the conclusion is that consciousness is an illusion (228, 385), but the book also analyzes consciousness as consisting of several different faculties–including agency, awareness, and qualitative experience–and treats them individually. The conclusion that "awareness is simply our ability to talk about our summary of the world and direct our computational abilities against portions of it" (423) is reminiscent of Dennett's in *Consciousness Explained*, a debt that Baum explicitly acknowledges. The explanation of the qualitative aspects of experience, on the other hand, is that they *have to* have the phenomenological properties that they do. Pain, for example, is a "raw penalty" and "intense hurt is precisely the experience we should expect" given that that is its nature (424). I have to admit that I don't follow this argument. It is clear (a) that the "penalty" message is important, and (b) that the ensuing behavior, such as withdrawal and future avoidance, is important. But why should we expect, *a priori*, that the pain should feel the way that it does? Why couldn't some other sensation have both communicated the appropriate message and caused the ensuing behavior? And why is it necessary for the message or the cause to be associated with a sensation at all?

According to *What is Thought?,* free will is also an illusion. Consistent with his background as a computer scientist, Baum frames the question of free will in terms of how it might be possible for people to create wholly new mathematical axioms, something computer programs cannot do. The book's position is that people actually do not create wholly new mathematical axioms–the axioms are innate. As Baum writes, "the mind is created by execution of the DNA program, so the new axioms must have been inherent in the DNA program…any 'new' axioms we generate can be derived from this stored information and thus do not represent genuinely new bits of information" (429-430). This is an old idea–one whose roots reach at least as far back as Plato's claim that knowledge is not acquired, merely recollected–but it is implausible on the face of it. According to *What is Thought?*, the idea of free will (among other things, the intuition that

"new" axioms really are new) is just another computational module, one that is convenient to adapt in order to efficiently explain behavior, both others' and one's own.

All in all, this is an interesting book with some intriguing ideas, but it does not quite find its niche. Attempts to provide commonsense explanations of abstruse topics in the theory of computation are welcome, and a willingness to struggle with hard philosophical questions is noteworthy and commendable. On the other hand, the explanations and arguments are not clear and simple enough for a truly popular audience, nor are they rigorous and complete enough for specialists. In the end, no reader is likely to be convinced by this book that thought is computation, that understanding is compression, that most of our concepts are innate, or that both free will and consciousness are nothing more than illusions.

Aarre Laakso received his Ph.D. in Philosophy and Cognitive Science from UC San Diego. He is currently a postdoctoral researcher in the Psychology Department at Indiana University, Bloomington.

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