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Holonomic Theories of Brain Functioning.

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The spectacular advances in brain science during recent decades have fostered great confidence among brain scientists. There is no sense of crisis or even malaise that might indicate incipient "scientific revolution" [1]. Of course, these advances have taken place primarily at neuronal and subneuronal levels. Although little is known about brain functioning at the highest levels of organisation, this is only to be expected, given the extraordinary complexity of the brain. It is confidently assumed that the continuation of present progress will eventually yield a brain science that will provide a theory of higher brain functioning.

It is widely believed, furthermore, that a technological instantiation of higher brain functioning is in fact already available in the guise of the digital computer. That is, the brain at its highest levels is thought to be a biological instantiation of a universal Turing machine. So the problem of higher brain functioning is in principle resolved, according to the mainstream, mostly tacit, view.

Two alternative conceptions of the computer brain should be distinguished. For the more traditional view, the order of input transduced at the receptors is conserved across a sequence of transformations, processings and analyses; ultimately the perceptual order of the world is constructed on the basis of conserved input order. There is a dark cloud on the horizon of this view, however, in that we are unable to trace the neural code of input past its initial registration in the intermediate layers of the cerebral cortex. Uttal [2] has suggested a number of candidate codes, and Thatcher and John [3] have suggested that the coding is a statistical tendency of large populations of neurons (the "hyperneuron"), but nobody presently knows the putative code that conserves input order along the way to perceptual order.

An alternative view is that there is indeed no conservation of input order. Instead, there is classification at increasingly higher levels of abstraction. Thus Hubel and Wiesel [4] state,

One can only assume that as the information on vision or touch or sound is relayed from one cortical area to the next the map becomes progressively more blurred and the information carried more abstract (p. 152)

The problem here is that the brain's information is abstract. Hubel and Wiesel detectors detect kinds. But perception is concrete; we perceive thing-kinds. The brain qua classifier give us the Cheshire Grin without the cat. So unless the whole problem of the concrete manifest world we perceive is swept under the rug by a dogmatic behaviorism, the theory that higher brain functioning is a matter of abstract classification is insufficient. Then the assumption of a putative code conserving input order must be refurbished, to be synthesized with the results of abstract classification so as to form the perceptual world.

So the view that the higher brain is a computer that conserves, transforms, processes, and classifies input order so as to synthesize a perceptual world has no substantial basis. Its great appeal, I believe, is only that it allows brain science to continue its molecular studies without feelings of insecurity. In what follows, I consider some alternative "holonomic" views of higher brain functioning.

The Law of the Whole

The alternative theories to be discussed have been generally called "holographic" rather than "holonomic". This unfortunately refers to the theory by a particular physical apparatus that illustrates holonomic principles rather than illustrates holonomic principles rather than by reference to those lawful principles. But let us access those "holonomic" principles - i.e., principles that follow the law of the whole - through description of a holographic imaging device.

The essential idea of holography is as follows. A coherent light source is split into two components. One component is diffracted from the object to be imaged and then recombined with the other component, the "reference signal", so as to form a wave interference pattern on a photographic plate is called the hologram. When the hologram is then transilluminated by the original coherent light source, the image of the object is reproduced. Multiple objects can be encoded with multiple reference signals to a single hologram.

The remarkable laws underlying holographic image reproduction are now emphasized. First, no image of the object can be found on examination of the hologram (unlike an ordinary photographic negative). The image is, as Bohm says, "enfolded" or "implicated" to the explicate hologram, and "unfolded" or "explicated" from the explicate hologram. There is what Bohm calls a "holomovement" between enfolding and unfolding. Second, each region of the hologram contains all of the information of the object (with loss of resolution and decrease of window size as the region becomes small). The enfolded order thus transcends any part of the hologram. Third, the enfolded order is indivisible; since in principle each point of the hologram enfolds the whole implicate order, distinction between points does not sever the whole. So "holonomy" entails an indivisible whole order enfolded within each point of an explicate order. The remarkable lawful properties of this explicate order are a function of the enfolded order.

Pribram's Holonomic Brain Theory

Pribram [6], [6a], [6b] has been the most persistent expositor of holonomic brain theory, although a number of other investigators also proposed the theory (e.g. van Heerden [7], Westlake [8]) Pribram's theory is easily conveyed by using the model of optical information processing systems. In optical systems, the explicate information to be processed is first Fourier transformed by passing through a lens (i.e., implicated) then processed by passing through a set of complex valued filters, and finally the filter output is subject to inverse Fourier transformation by passing through a lens (i.e., explication). Thus the essential process is that of input-implication, processing in the transform domain, and explication-output.

Similarly in Pribram's theory the input to the brain is implicated (Fourier transformed or Fourier-like transformed), processed by passing through neural filters that are neural equivalents to wave interference patterns, and then explicated (inverse Fourier transformation) as perceptual order. memories are stored in implicated form. It is important that the brain is as empty of order as a blank photographic plate, until input loads it with implicate order.

Pribram's theory makes use of the remarkable properties of holonomic system as follows. Since

memories are stored in implicate form, memory is distributed rather than directly localized, in accordance with Lashley's mass action law. Further-more, memories are content-addressable. Similarity, recognition and invariance are easily determined in this holonomic system, since such functions as cross correlation, convolution, and autocorrelation are instantaneously calculated by passing the implicated input order through the proper neural filter.

Viewed in this way, Pribram's theory is a variant of the traditional view of information processing discussed above, in which input order is conserved in some code across a sequel of transformations and processing. In the holographic theory, that code is an implicate code and the calculations take place in the transform domain. Put abstractly, what is being said is that the proper mathematical description of information processing in the higher brain requires complex numbers and requires what Yevick [9] calls a "Fourier logic", rather than the binary numbers and Boolean logic of digital computers.

An Apriori Holonomic Theory

An alternative holonomic theory of higher brain functioning 20 emphasizes that perceptual order is "apiori". The technical exemplar here is not a classical holographic device or optical informational processing system but computer-generated holographic imaging. Now the complex values of a hologram can be calculated by a computer and in the computer output a hologram can be actually formed that unfolds the order of some object. What is remarkable here is that the object enfolded need not actually exist. The computer can by purely abstract means generate a hologram that enfolds a number of objects which are purely "imaginary". On transilluminating such a computer generated hologram with the proper signal, we might see a scene that no one has ever seen before!

Computer generation of holograms is, of course, a very tedious calculation. But suppose the brain were wired so as to be able to generate neural holograms of great complexity, indeed of such richness that many orders would be enfolded. At the limit, all possible order might be enfolded to this neural hologram, which would be a virtual holoworld. We may suppose that a universal holoworld is generated by purely random mechanisms, as if - to use the optical analogy - waves of all frequencies and amplitudes were superposed into an infinitely rich interference pattern. That is, autonomous brain mechanisms during waking (and REM sleep) generate by random means a holoworld of such richness that it enfolds all possible perceptual worlds. This holoworld would then be apriori, generated by the genome. It would follow that all explicate worlds that we might perceive are in fact apriori implicate rather than the brain being empty, a tabula rasa, to be filled by experience. What insures for this apriori holonomic theory that the perceptual order unfolded from the apriori holoworld in fact provides for survival and reproduction as necessitated by evolution ?

It must be that the rules for explicating a particular enfolded world are a function of input to the brain. We may suppose that input is classified and the output of classification is functionally the rule for explicating a particular world form the holoworld. That is, particular invariant structures within the input flux (as Gibson [11] discusses) afford or enable particular classifications to be made, and then the classification signals explicate an apriori implicate world. If the classifications are good ones, then survival and reproduction are assured. In effect, input selects implicate worlds from the holoworld for unfolding.

Evaluation

Decisive data on higher brain functioning is not available as initially discussed, so it is not possible to choose between the various theories. But from what we do know, holonomic theories are at least tenable, since the evidence is quite good that the brain in fact performs a Fourier-like transformation on input [12]. Whether the received views of the brain as computer or the revolutionary holonomic view will be supported remains for future research to out.

But how might we presently evaluate apriori version of holonomic brain theory against the aposteriori (Pribram's) version in which experience loads an empty brain? Lacking data, we can only evaluate how these theories fit with other sets of concepts. It is my contention that the apriori version is essentially oriental in spirit whereas the aposteriori version is essentially occidental in spirit.

The apriori version is radically different. Now "all words lie within". There is an infinite ground - the holoworld - with an indivisible, distinctionless, enfolded order. It is this infinite ground source of all explicate worlds that is fundamental. The explicate world with its distinctions is secondary, derivative, a function of our own "doing" qua rule-governed actions of explicating particular worlds from the holoworld. *maya*. What lies behind the explicate world that we create in virtue of the classifications we impose on input is the non-dual whole *advaita*.

The apriori version makes intelligible, in the physical realm but not the spiritual realm, the "paradox of the absolute:(attributed to Sri Ramana Maharishi by Wilber) [13].

The world is illusory.

Only Brahmin is real.

Brahmin is the world.

Let me emphasize that I do not seek to reduce the spiritual to the physical, but only to see what Wilber [13] calls the "reflecting downward" of the higher spiritual realm in the lower physical realm. That is, all of the lower is in the higher but not all of the higher is the lower. (Wilber [13] p. 261)

So "the world is illusory" in the reflected downward sense that the perceived world is derived by explication from a more fundamental apriori holoworld. "Brahman alone is real" in the reflected downward sense that the infinite holoworld of apriori implicate orders is fundamental. And "Brahman is the world" in the reflected downward sense that all worlds are enfolded within the holoworld. Thus the apriori vision of holonomic brain theory has a strong affinity with the oriental "mystical" tradition, whereas the aposteriori version of Pribram has an affinity with the occidental "analytic" tradition.

Summary

Received views of higher brain functioning, enamoured of the contemporary computer, are not grounded in empirical findings. Alternative theories of brain functioning which are "holonomic", i.e., follow the law of the whole, were considered. Pribram's aposteriori version of holonomic theory takes optical information processing system as technological exemplar and is rooted in the occidental analytical tradition, where the brain is conceived to be an empty tabula rasa which is loaded by experience. An apriori version of holonomic theory takes computer generated holograms as exemplar

and is rooted in the oriental "mystical" tradition. For the apriori version, all worlds lies within, enfolded within an autonomously generated holoworld. Mental classifying actions unfold particular perceptual worlds from the apriori holoworld. Invariant structures within input afford particular classifications, which generate by explication particular explicate perceptual worlds.

It is at present highly premature to close off consideration of higher brain functioning. Instead speculations, even when grounded in spiritual considerations, may be of heuristic value to empirical brain science.

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