Nonlinear Time and the Human Brain

Frederick Turner
University of Texas at Dallas

Abstract

Emergent features of physical objects imply emergent features of space and time. Time evolved; highly evolved objects require a range of temporalities, from primitive reversible ones to advanced irreversible ones, to exist in and to be described. Quantum events are essentially timeless, as are the correlations among them. Human beings and other advanced animals should be able to use their nervous systems as quantum amplifiers to detect quantum correlations between present events and future events, and thus may have a weak but significant capacity for precognition.

If we take space and time to be inseparable from and correlated with the physical objects and events that constitute the universe, as the theory of general relativity maintains, then we must expect that space and time evolved with the rest of the universe, from the Big Bang onwards. We should not assume that sophisticated features of time or space preexisted the sophisticated physical and informational structures of complex chemistry, life, and mind that demanded them. Space and time are whatever environment a system of a given complexity requires to deploy and display its features; there is no need for space and time to be anything else. Since many of a system's features will be emergent, that is, novel and specific to its particular form of organization, time and space must possess emergent features also, and perhaps the continuing capacity to produce new emergent features.

Among topologists, nonlinear mathematicians, superstring theorists, and others, there is already speculation that the most primitive features of space itself emerged as solutions to logical problems and paradoxes inherent in mathematics. Such problems include the need for an imaginary number line to deal with square roots of negative numbers; the infinite series of "chinese boxes" required by Gödel's incompleteness theorem, each of which confirms the truth of certain self-referential problems unsolvable on the previous level; and the constructed dimensions of fractal geometry, whereby one-dimensional lines can achieve virtual two-dimensionality by infinite recursion, and planes can aspire to the continuity and density of solids through complex folding. Once space exists, new paradoxes arise, which were resolved by the springing into existence of the laws of physics; and these laws in turn generate contradictions unless new features emerge, such as the most primitive characteristics of time, the bifurcation of the primal supergravity into the four forces of ordinary physics, and the expansion of the universe. J.T. Fraser has shown how more sophisticated modes of time, which he calls "temporalities," arise with the evolution of more complex structures, such as stable subatomic particles, molecules, crystals, and living organisms.

Thus the complex and elaborate features of space, and especially of time, as we observe them today, are the product of a long coevolution with the structures of matter, energy, life, and mind in the universe. If we take, for instance, an English sentence, which is a bona-fide object in the physical world, we can, by a kind of temporal archeology, discover in it several layers of time-evolution. At the top is its sophisticated tense-structure, implying a complexly branched set of options, possibilities, virtual, conditional, and subjunctive times, and a clearly distinguished past, present, and future. On a lower level the sentence is the utterance of an animal, with a simpler set of motives and a more rudimentary and vaguer time-geometry, but with a time-sense that contains a past and future, a definite direction, and continuity. The sentence is also a feature of molecular structure, and as such it possesses continuity and direction (it is thermodynamically not the same backwards as forwards), though it lacks on this level any clearly distinguishable present moment, and thus can scarcely be said to have a past and future except as the gradient of its increase of entropy. More primitively still, the sentence is a vibration of elementary particles, which are directionless and reversible (according to the Feynman diagrams) and whose time is thus barely distinguishable from space. Finally, the sentence is a quantum

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phenomenon, lacking even continuity and determinate identity in time. All these times are subsumed within, and organized by, our sophisticated human experience of time.

If new times emerged with the new, more complex organisms that support and are contained by them, then we are entitled to ask what will be the next emergent temporality beyond our own. This is an important question, since as we have seen, later temporalities come to contain and retroactively make sense of earlier ones. That emergent temporality will presumably do the same thing with us, and is thus in a sense already containing our more primitive time-environment and making sense of it. John Archibald Wheeler's Anthropic Principle can be seen in this light as a proposal for an actual mechanism whereby later temporalities can retroactively condition earlier states of the universe. In his theory, since quantum events require an observer to collapse their wave function, and all acts of observation take place after the events they observe (because of the limit-speed of the propagation of information), and the Big Bang was a quantum event, and only one state of the early universe (out of many possible states into which it could have collapsed) could have brought about the existence of observers like ourselves, the existence of present observers was necessary to trigger the Big Bang. But since all events contain a quantum substructure, all events, to the extent that quantum effects are amplified up into the macrocosm, must be weakly affected by the existence of later observers of them.

The qualification in this last formulation regarding the need for a quantum amplifier is quite important; for quantum indeterminacy is usually swamped and suppressed in the macrocosm by the collective properties of molar matter, which is strongly determined by its own past state. In other words, when the universe cooled sufficiently to permit the collapse of energy into matter, that collapse included a change from temporal symmetry into temporal asymmetry, with a preference for cause and effect working "forwards" in time. But the potential for a sort of two-way, or rather directionless, correspondence between events lingers on as a fossil on the quantum level, showing up for instance in the paradoxes of the Bell and Aspect experiments, and in the approach to entropyless computation in the work of Rolf Landauer. If that potential could be harnessed, for instance by some sort of "butterfly effect," so that the collective behavior of matter did not damp out but rather multiplied the sensitivity of the quantum to other events both past and future, then in theory a very weak kind of time machine might be possible.

Evolution did not of course cease with the appearance of matter. The emergence of life carried with it a greater and greater concern with the future, since reproduction constitutes a preemptive attempt by a living species to seize the future for its ecological niche. It would make a great deal of sense for any organism to be able to predict the future (or rather I should say the futures, for reasons that will become clear). The dramatic development of neural machinery for integrating and extrapolating past experience that happened over the course of biological evolution was clearly driven by the premium on prediction. My hypothesis is that the competition for the future was so severe that such methods--using memory to collect, and neurocircuits to analyze, past information--were no longer adequate for more advanced species. Such methods would be excellent for predicting the behavior of simple molar matter, but would be less useful in predicting the activities of highly complex organisms, with many degrees of internal feedback, such as other advanced animals. It would be a superb adaptive development if a mechanism could be developed--call it hunch, intuition, the aesthetic sense, the power of divination, inspiration, or divine visitation--that could be sensitive enough to pick up and amplify the correspondences between quantum events in the brain and future events; in other words, to be able to detect the presence and tendency of future observers, collapsing their wave functions. In fact the architecture and electrochemistry of the neurons, their sensitivity and their readiness to fire massively when tiny but critical thresholds are crossed, their extensive use of free electrons in determining threshold-crossings, their collective ability to form positive feedback circuits that retain and transmit complex, robust and sensitive waveforms--all these features suggest the capacity to pass minuscule signals up from the subatomic realm to that of gross anatomy.

In other words, we can regard the brains of humans and other advanced animals as among other things very sophisticated quantum amplifiers, multiplying the effect of quantum events into the macrocosm, editing them in terms of past experience, and integrating them into the pattern of motivation. We are, already, weak time machines.

The development of chaos theory, and the discovery of strange attractors for physical processes, have added a new twist to this line of speculation. There is a sense in which the strange attractors of nonlinear dynamical systems preexist the actual events--the dripping faucet, the orbiting star-cluster, the weather-system--that plot them out. New research indicates the powerful presence of strange attractors as the guides of general fetal development, early brain growth, and normal brain function. The forms of the attractors seem to be timeless, although since they are infinitely deep, containing new detail at ever higher levels of magnification, they have never been fully plotted in reality. Any organism that could recognize the general style and trend of a strange attractor would have a good guess at how it would look after further iterations, and thus a weak but useful grip on the future. Our sense of the aesthetic beauty of the attractors--consider the instant popularity of the Mandelbrot Set--may be evidence of the brain-reward that should attend such complex recognitions. An interesting question for further investigation would be whether the existence of the strange attractors has anything to do with the weak backward causality (or "final" causality, as Aristotle put it) that we have already suggested. Many physical events, such as the formation of whorls of turbulence or the sudden crystallization that takes place in a phase-change, would be unpredictable by any computational system smaller than the universe, and we might well wonder how they "know" in realtime what to do next. Perhaps the strange attractors are the future's way of telling them how to behave so as to bring about future observers.

One problem with this line of speculation is that it might seem to suggest that the future is fixed, since it is already "there," in the sense that its observers are collapsing our wave functions. This would be a problem if we conceived of the future as being single. However, there is no reason why we should not conceive of an almost infinite number of possible futures branching out from every indeterminate event, all thinly and weakly actual, according to their relative probability. These futures would naturally be in competition with each other, each striving to observe its earlier states, which it would share with its rivals, into such collapses that would be most favorable to its own existence. The strongest futures would have the strongest voice--or eye!--in staging a given collapse; and the occasional consensus among futures would amount to a probability of one, and correspond to a deterministic event. All futures would seem to agree, for instance, on the regularity of lunar eclipses--a universe in which they were unpredictable would be pretty inimical to any kind of coherent observer. In this interpretation human choice would have enormous ethical importance, since it would help determine the whole future, and even in some senses the past, of the universe itself.

If time, as suggested here, contains two directions of causality, a strong forward one and a weak backward one (or, more precisely, forward causes and backward "correspondences" or "evidential constraints"), then a feedback loop has been completed and time itself may be considered to be nonlinear and perhaps self-organizing, as nonlinear systems tend to be. If the temporal universe is such a system, with a bottom-up material causality modified by a top-down final causality, and if the human brain is designed to recognize the forms of this feedback, then any computational engine that would emulate human intelligence must take such considerations into account. The language of the traditional arts and humanities, and of the many religions of the world, constitute an ancient and empirical body of knowledge about teleology, final causes, inner aesthetic forms, prophecy and hunch. Perhaps they have a contribution to make in the pursuit of artificial intelligence.