Alexander J. Argyros

TOWARDS A VIEW OF TIME AS DEPTH

One of the more recalcitrant issues in the philosophy of time concerns the question of temporal asymmetry. Some theorists, many of them, like Einstein, physicists, believe that time is fundamentally reversible. According to this view, the physical universe is indifferent to the direction of time; consequently, something like an arrow of time is held to be a human subjective imposition on an otherwise temporally isotropic world. Another position, held by Alfred North Whitehead and contemporary process philosophers, maintains that temporal asymmetry is a primitive condition of the universe, and that therefore even the most basic physical processes, such as those occurring at the subatomic level, display a distinct temporal direction. Finally, the philosopher of time J.T. Fraser (1978) claims that temporal asymmetry is an emergent feature of the universe, appearing for the first time with biogenesis. According to Fraser, with the emergence of life comes a present, or "now", a temporal dimension whose absence in more primitive levels of cosmic evolution prohibits the attribution of an arrow of time to any pre-biotic entity.

https://doi.org/10.1177/039219219003815102 Published online by Cambridge University Press

In this paper, I will argue that any theory of time that postulates that temporal asymmetry is merely a human illusion is untenable, and that, as a consequence, either the Whiteheadian view, Fraser's or a synthesis is likely to represent most accurately the nature of time. Then, using ideas stemming from the study of dissipative thermodynamic systems and chaos theory, I will attempt to present a view of time that respects Fraser's evolutionary temporal model while removing the awkwardness inherent in any attempt to date an arrow of time from the first appearance of biological entities. Specifically, I will claim that Fraser is correct in asserting that time has evolved along with everything else in the universe, but that he is incorrect in assuming that an arrow of time is the product of the emergence of life. Instead, it is much more reasonable to assume that an arrow of time is itself an evolving feature of our universe, developing from the faint temporal asymmetries associated with those initial inhomogeneities that kicked the early universe out of thermodynamic equilibrium and set its evolution in motion, to the sharply anisotropic temporality of the human cultural sphere.

THE ORIGINS OF TEMPORAL ASYMMETRY

In order to frame the arguments that follow, let me briefly outline Fraser's theory of time. Fundamentally, Fraser claims that time is itself an evolving feature of the universe, with increasingly complex temporalities serving as the condition of possibility of the successive stages of cosmic evolution described by many cosmologists. Specifically, Fraser believes that time has evolved through the following *umwelts*:[1] The most primitive temporality is the atemporal *umwelt*, typical of objects with zero restmass or of distances on the order of the Planck length. Prototemporality describes the stochastic and probabilistic temporality of the quantum realm. Macroscopic objects are eotemporal, their level-specific temporality allowing pure succession with no preferred

[1] An *umwelt* is defined as "the level-specific realities of the different levels of nature as revealed through scientific experiment and theory" [Fraser, 1987, p. 368]. It can also be defined as the horizon of potential information available to entities of a given level of complexity.

https://doi.org/10.1177/039219219003815102 Published online by Cambridge University Press

direction. With the emergence of biotemporality a now comes into being and with it temporal anisotropy. Human beings exist in a nootemporal *umwelt*, in which time is sharply asymmetrical and largely inhabiting symbolic or counterfactual dimensions. Lastly, Fraser posits a sociotemporal *umwelt*, the time of large-scale social configurations.[2]

Fraser's temporal cosmology is at odds with a long tradition in the natural sciences that maintains that time is not an objective component of the physical universe. Stephen Hawking (1988) states flatly that "the laws of science do not distinguish between the forward and backward directions of time", and Einstein believed that time was a product of human subjectivity and was without a physical basis: "For us believing physicists, the distinction between past, present and future is only an illusion, even if a stubborn one" (Cited in D.R. Griffin, 1986, p. x). Fraser's evolutionary view of time attempts to correct the widely held view that time is at best a subjective quality having no basis in objective reality. However, despite the beauty and explanatory power of Fraser's theory of temporal evolution, it does present a number of serious problems. For the sake of simplicity, let me reduce them to two seminal types.

[2] Perhaps a summary of Fraser's *umwelts* would help the reader at this point. According to Fraser (1987), time has evolved through the following levels:

Atemporality describes the world of electromagnetic radiation. "Atemporal conditions do not signify nothingness but rather that the proper time of particles that travel at the speed of light is zero" (p. 368).

Prototemporality, the time of elementary particles, "is an undirected, nonflowing as well as fragmented (noncontinuous) time for which precise locations of instants have no meaning. Events in the prototemporal universe may only be located in a statistical, probabilistic manner" (p. 368).

Eotemporality is the temporality of massive matter. "It is a continuous but nondirected, nonflowing time to which our ideas of a present, future, or past cannot be applied" (p. 368).

Biotemporality, the time of living organisms, "characterized by a distinction among future, past, and present, but the horizons of futurity and pastness are very limited..." (pp. 368-369).

Nootemporality is the temporality of the fully developed human mind. "It is characterized by a clear distinction among future, past, and present; by unlimited horizons of futurity and pastness; and by the mental present..." (p. 367).

Sociotemporality is "the postulated level-specific reality of a time-compact globe. The study of sociotemporality encompasses issues in the socialization of time and in the collective evaluation of time" (p. 368).

First, if an arrow of time first appears with the emergence of biological entities, in what sense can the history of the universe before that "moment" be called evolution? It would appear that by Fraser's own definition, the atemporal, prototemporal and eotemporal *umwelts* could not be situated in a series with a preferred direction, since the very notion of temporal progression only becomes thinkable with the emergence of the biotemporal present. And yet, Fraser clearly subscribes to an evolutionary view of time in which there is a logical vector leading from atemporality to biotemporality, implying that evolution itself has an arrow of time.

Gardner (1979), Prigogine (1984) and Hawking maintain that such a cosmological arrow guarantees a temporal asymmetry on the largest of scales. This asymmetry can be understood simply as the direction of cosmic expansion—"the cosmological arrow, the direction of time in which the universe expands rather than contracts" (Hawking, 1988, p. 152) or in an evolutionary sense—"If we assume that the universe started with a Big Bang, this obviously implies a temporal order on the cosmological level" (Prigogine, 1984, p. 259). Since Fraser's model requires that temporal direction be meaningless in the purely physical *umwelts*, his evolutionary model would have to maintain that the cosmological arrow is the result of retroactive observer participancy. Although this view, a version of Wheeler's (1988) theory of observer participancy in the self-synthesis of the world, is undoubtedly true at a certain level of description, it is still somewhat unconvincing to argue that had the universe ended before the appearance of biotemporal entities it would not have evolved in any meaningful way.

A variant of the cosmological arrow view maintains that it is not simply entities and forces that evolve, but also the basic regularities or laws constitutive of an integrative level. According to Griffin, the evolution of the fundamental laws of matter should itself display an arrow of time: "If this idea is accepted, then time, with its difference between past, present, and future, its 'moving now', and its irreversibility in principle, will have to be recognized as applying to the fundamental laws of physics, for it will thereby be recognized that the so-called fundamental laws themselves have a history, that their importance in the actual world had a beginning and will have an end" (Griffin, 1986,

https://doi.org/10.1177/039219219003815102 Published online by Cambridge University Press

p. 28). In sum, a cosmological arrow of time, whether it is measured against the scale of evolving laws, increasing complexity or expanding space (all of which I believe to be descriptions of the same phenomenon) would define temporal asymmetry as the condition of possibility of evolution itself, thereby making Fraser's cosmology incoherent.

Second, Fraser's refutation of the widely held theory that the Second Law of Thermodynamics (the theory, developed by the Viennese physicist Ludwig Boltzmann in the 1870's, that the entropy, or the degree of disorder, of an isolated system has a very high probability of increasing over time) guarantees a universal arrow of time is less than satisfactory. According to Davies (1983) there is a paradox inherent to the statistical nature of the Second Law. Statistically, it guarantees a macroscopic temporal asymmetry, yet microscopically, at the level of individual entities, time appears to be reversible: "All physicists recognize that there is a past future asymmetry in the universe produced by the operation of the second law of thermodynamics. But when the basis of that law is carefully examined, the asymmetry seems to evaporate" (Davies, 1983, p. 125). Consider a bottle of perfume whose cap has been removed. Clearly the perfume will evaporate and permeate the room. Equally as clear is the improbability that the vector of its diffusion would be reversed, with vaporized perfume gradually finding itself back in the bottle in liquid form. According to Davies, "the evaporation and diffusion of the scent provides a classic example of asymmetry between past and future" (Davies, 1983, p. 126). Yet, Boltzmann's equations are essentially statistical in nature, guaranteeing that a large number of molecules will tend to find a state of maximum disorder (because there are far more such possible states than there are ordered states). "However," adds Davies, "any given individual molecular collision is perfectly reversible. Two molecules approach, bounce and retreat. Nothing time asymmetric in that. The reverse process would also be approach, bounce and retreat" (Davies, 1983, p. 126). Davies's solution to the dilemma is to argue that it is in fact a level confusion, an attempt to compare temporalities that belong to two different orders of organization: "The mistake is to overlook the fact that time asymmetry, like life, is a holistic concept, and cannot be reduced to the proper-

https://doi.org/10.1177/039219219003815102 Published online by Cambridge University Press

ties of individual molecules. There is no inconsistency between symmetry at the molecular level, and asymmetry on a macroscopic scale. They are simply two different levels of description'' (Davies, 1983, p. 127).

Davies is undoubtedly correct, but his resolution does not adequately address the question of the emergence of an arrow of time. For even if temporal asymmetry as guaranteed by the second law of thermodynamics is a holistic phenomenon, it certainly is applicable to a universe that has not as yet reached the biotemporal *umwelt*. Holism, as the system behavior of individual entities, is a possible state of objects in any *umwelt* with the possible exception of the atemporal, consequently Davies's synthesis of temporal asymmetry and symmetry would introduce an arrow of time to all of Fraser's integrative *umwelts*. If that is the case, then the possibility of temporal asymmetry is indeed dependent on entropy and not, as Fraser would have it, on the existence of a biological present.

Fraser's response to such an attempt to anchor temporal asymmetry in the fundamental nature of the universe is to argue that the second law of thermodynamics by itself cannot guarantee an arrow of time. Fraser maintains that eotemporal entropy only appears to have a preferred direction to a nootemporal observer. A human observer, rooted deeply in an anisotropic temporality, perceives entropy as displaying a preferred direction, but in fact he/she is only observing the world through a kind of temporal prison-house. The second law of thermodynamics is only temporally asymmetrical when viewed from a higher temporal *umwelt* than that associated with non-living matter, so to assume that it is itself possessed of an arrow of time would be a kind of temporal imperialism.

Fraser's basic argument is that primitive *umwelts* cannot be temporally asymmetrical because they do not possess a present. Although he focusses on the statistical nature of the second law of thermodynamics, I think his main point is that whether one looks at pre-biotemporal *umwelts* holistically or reductively, that is, either as aggregates or as mixtures of individual entities, they are in principle presentless and thus indifferent to the direction of time. Unfortunately, it is not at all clear that only biological entities are able to define a present. An opposing view of time is held by process philosophers such as Griffin who, following in the tradition of Whitehead, maintain that temporal flux is a primitive feature of our universe: "For Whitehead, the reality of time, with its irreversibility, is based on the fact that the actual world is composed exhaustively of momentary events that include, partially but really, preceding events, which had in turn included previous events, and so on back" (Griffin, 1986, p. 10).

Griffin considers even the most elementary of particles as so many processes, with their own division into past, present and future:

> Rather than thinking of enduring particles as the fundamental entities of the world, Whitehead sees each enduring object as composed of a rapidly occurring series of events, each of which includes aspects from its predecessors in that enduring object but also aspects from other prior events as well. Hence, Whitehead opposes the widespread view that an individual atom is timeless; rather, it is a "temporally-ordered society" of actual occasions... Since an individual atom (or even electron) has a temporal structure, time or temporality does not first arise as a statistical effect of the interactions among a multiplicity of atoms. (Griffin, 1986, pp. 10-11).

While process philosophers would certainly take issue with Fraser concerning his interpretation of the second law of thermodynamics, the real point or contention is whether a present is a universal temporal feature or whether it indeed becomes thinkable only after the emergence of life. Accepting Fraser's definition of temporal asymmetry as needing, as a minimal condition, a present, process philosophers argue that everything in the universe, from nootemporal events to subatomic particles, is a process consisting of potential events passing into actuality through the present. Specifically, Griffin defines the future as the realm of as yet indeterminate possibility, the past as the set of events that are determinate, and the present as the instant of choice: "The present is the realm in which decisions are being made: some possibilities are being turned into actualities while other possibilities are being excluded from actualization" (Griffin, 1986, p. 2). Becoming, the continuous transformation of indeterminism into determinism, is a fundamental property of being. Therefore, since the present divides the world into two asymmetrical regions, that of

https://doi.org/10.1177/039219219003815102 Published online by Cambridge University Press

potentiality and that of actuality, an arrow of time is not restricted to biotemporal entities, but is a primordial feature of the universe.

Process philosophy views the second law of thermodynamics as merely one manifestation of a much deeper principle, that temporal anisotropy underlies all processes. As such, the Whiteheadian view of time is squarely at odds with Fraser's theory of the evolution of time and, in a more limited way, with Davies's idea that time asymmetry is the property of collectives, not of individual physical particles.

THE TIME OF DISSIPATIVE SYSTEMS

I would like to propose a resolution to this apparent dilemma, a resolution that would simultaneously respect Fraser's basic temporal architecture and allow for a pre-biotemporal arrow of time. I will begin by returning to Fraser. According to Fraser, evolution is fueled by irresolvable conflicts that develop within a given *umwelt*:

> The theory of time as conflict identifies each of the major integrative levels with certain unresolvable conflicts. By conflict is meant the coexistence of two opposing trends, regularities, or groups of laws, in terms of which the processes and the structures of the integrative level may be explicable. By unresolvable is meant that, by means indigenous to an integrative level, its conflicts may only be maintained (and thereby the continued integrity of the level secured) or else eliminated (and thereby the level collapsed into the one beneath it). If the conflicts vanish, so does the integrative level. However, the unresolvable conflicts of each level can and do provide the motive force for the emergence of a new level. But a new *Umwelt*, from its very inception, may once again be identified with certain unresolvable conflicts of its own. (Fraser, 1978, p. 27).

For example, Fraser speculates that the competing demands of growth and decay constitute a biotemporal conflict resolvable only in the nootemporal *umwelt*. I would like to generalize Fraser's idea to include states of non-equilibrium at all integrative levels. While there must be a minimum amount of stability in an *um-*

https://doi.org/10.1177/039219219003815102 Published online by Cambridge University Press

welt for it to be recognizable as a stable level of evolutionary complexity, it cannot be in perfect equilibrium if it is to be pushed to transcend itself. In other words, an integrative level must have enough stability in order to have a usable identity, but not so much that evolution becomes unnecessary or unthinkable.

Fraser's understanding of time as conflict accounts for the need for temporal instability within a given integrative level, however in the light of recent work in the science of self-organizing systems, it appears that in order to avoid the trap of stasis, Fraser must admit an element of temporal asymmetry into the most primitive *umwelts*. In order to see why this is the case, it would be well to recall that arguments such as Davies's maintain that the universe is divided into two temporal camps: microscopically, at the level of particles, the laws of physics are indifferent to the direction of time; macroscopically, when societies of particles are considered, the second law of thermodynamics guarantees a statistical arrow of time. And, even if we complicate this schema a little by adding a third category, the negentropic arrow of self-organization, it still suggests that there might be entire *umwelts* that know no time asymmetry.

Although primarily concerned with biological systems, Brooks and Wiley (1988) make essentially such a distinction concerning the whole of the natural world:

> The natural systems studied in physics, chemistry, and biology are made up of simple microscopic components. The laws describing the behavior of individual components are time-invariant. Macroscopic systems made up of these components, however, always exhibit one of two forms of irreversible behavior. Those that follow the "arrow of time" (Eddington, 1928) move in the direction of decreasing order and organization... In contrast, other systems follow the "arrow of history" (Layzer, 1975), and move spontaneously toward states of higher order and organization. These systems are called "self-organizing". (Brooks and Wiley, 1988, p. 51).

Brooks and Wiley recognize two forms of irreversibility—classic thermodynamic decay and self-organization. They contrast these global, stochastic processes to microscopic interactions which they define, as does Davies, as temporally symmetrical.

Two components of the Brooks and Wiley position need to be

https://doi.org/10.1177/039219219003815102 Published online by Cambridge University Press

emphasized: one, their microscopic/macroscopic opposition; and two, their focus on the temporality of self-organizing systems. Both of these ideas receive extensive treatment in the work of Prigogine, although with a somewhat different emphasis. On one crucial point, however, Brooks and Wiley are in complete agreement with Prigogine—dissipative, far-from-equilibrium systems are inherently temporally asymmetrical:

> Some systems begin as collections of particles having no time asymmetry (no arrow of time). Fluctuations in the surroundings, the boundary conditions, may cause instabilities in the system (Jantsch [1981] termed this the "penetration of the environment into the system"). As a consequence, the system may "react" or "respond" in a physical sense. This would be accompanied by the production of entropy that would then be "exported" from the system into the surroundings. The system might then transform into a nonhomogeneous, or ordered, state. If this occurs, a time asymmetry will have been produced and the system may persist in an ordered state. This process is referred to as "order out of chaos" or "order through fluctuations" (Prigogine and Stengers, 1984). We will call it the "dissipative structures idealization", because it applies to systems whose macroscopic behavior can be explained totally by reference to products dissipated from the system irreversibly. (Brooks and Wiley, 1988, p. 58).

The Wiley and Brooks interpretation of self-organizing systems theory is half way between Fraser's position and that of Griffin. Whereas Fraser believes that an arrow of time only comes into being with the emergence of life, and whereas Griffin argues that temporal asymmetry is a primitive aspect of our universe, Wiley and Brooks maintain that although microscopic particles display eotemporal directionless succession, non-equilibrium systems that are either decaying or self-organizing describe a temporal direction. If that is the case, as evidence from diverse fields is suggesting, then Fraser's model will have to be amended. An arrow of time appears to be tied less to biological systems than to certain instabilities or inhomogeneities liable to appear anywhere in the natural world.

Prigogine makes the points clearly: "All dissipative systems have a preferential direction of time" (Prigogine, 1986, p. 234). Whenever symmetry is broken in a dynamic or thermodynamic system, irreversibility and an arrow of time occur. Therefore, if, as many cosmologists have speculated, the entire universe is one unimaginably complex far-from-equilibrium self-organizing system, then an arrow of time must be an inherent property of an evolving cosmos. Therefore, temporal asymmetry cannot simply be an epiphenomenon of macroscopic aggregates, but must, as process philosophy maintains, be a feature of the microscopic realm.

Prigogine's (1984) central thesis is that contemporary science is undergoing a paradigm shift from a conception of nature as fundamentally deterministic and reversible to a point of view that is sensitive to the tremendous number of processes that are probabilistic and irreversible:

> We have repeatedly stated in this book that the reconceptualization of physics going on today leads from deterministic, reversible processes to stochastic and irreversible ones. We believe that quantum mechanics occupies a kind of intermediate position in this process. There probability appears, but not irreversibility. We expect... that the next step will be the introduction of fundamental irreversibility on the microscopic level. In contrast with the attempts to restore classical orthodoxy through hidden variables or other means, we shall argue that it is necessary to move even farther away from deterministic descriptions of nature and adopt a statistical, stochastic description. (Prigogine, 1984, p. 232).

Prigogine is committed to the view that although nature displays many reversible processes, such as those that Fraser labels eotemporal, the processes that will prove of ultimate interest will be those displaying temporal polarization. Furthermore, he is convinced that macroscopic irreversibility is not simply a product of the laws of large numbers but is in fact the expression of an underlying microscopic arrow of time:

> As we emphasized repeatedly, there exist in nature systems that behave reversibly and that may be fully described by the laws of classical or quantum mechanics. But most systems of interest to us, including all chemical systems and therefore all biological systems, are time-oriented on the macroscopic level. Far from being an "illusion", this expresses a broken time-symmetry on the microscopic level. Irreversibility is either true on all levels or on none. It cannot emerge as if by a miracle, by going from one level to another." (Prigogine, 1984, p. 285).

https://doi.org/10.1177/039219219003815102 Published online by Cambridge University Press

Just as many cosmologists believe that the essentially featureless early universe must have begun its evolution because of a break in symmetry, Prigogine speculates that temporal asymmetry may be the seed out of which complexity arises at all levels of description. If that is the case, although some *umwelts* may be mainly atemporal, their very existence as well as the impetus pushing them towards self organization into more complex *umwelts* must be due to an element of internal temporal polarization. In other words, deterministic systems are the fossilized record of generative irreversible processes.

In general, since they could run backwards as easily as they do forwards, deterministic systems display no temporal polarity. If a Laplacian demon knew the initial conditions of such a system with infinite accuracy, he could predict its state at any moment in the future, so its future would be in essence no different from its past. Past, future and present would coexist in a kind of atemporal plenum. We know, however, that many systems in nature are not linear or deterministic but are more properly described as chaotic. One of the central features of chaotic systems is that even though they describe recognizable attractors, the exact trajectory of their development is so sensitive to initial conditions that it is in principle impossible to map it in advance. The only way to know exactly what a chaotic attractor will look like is to run the recursive algorithm that generates it:

> The randomness of chaotic motion is therefore fundamental, not merely the result of our ignorance. Gathering more information about the system will not eliminate it. Whereas in an ordinary system like the solar system the calculations keep well ahead of the action, in a chaotic system more and more information must be processed to maintain the same level of accuracy, and the calculation can barely keep pace with the actual events. In other words, all power of prediction is lost. The conclusion is that the system itself is its own fastest computer. (Davies, 1988, p. 54).

Prigogine has sought to ''unify dynamics and thermodynamics, the physics of being and the physics of becoming'' (Prigogine, 1984, p. 277). The result is that certain systems can be shown to be inherently unstable, probabilistic, entropic and temporally polarized: ''It also seems quite remarkable that irreversibility emerges, so to speak, from instability, which introduces irreducible statisti-

https://doi.org/10.1177/039219219003815102 Published online by Cambridge University Press

cal features into our descriptions. Indeed, what could an arrow of time mean in a deterministic world in which both future and past are contained in the present?'' (Prigogine, 1984, p. 277). In a sense, Prigogine's goal is to thwart the rapacious grasp of Laplace's demon. He would like to demonstrate that temporal irreversibility is not the product of human ignorance, but an objective property of certain natural processes. If that is the case, time's arrow is not simply a macroscopic statistical phenomenon that could in principle be reduced to timeless determinism by an omniscient observer, but an intrinsic feature of many systems. Simply, Prigogine would like to show that in such systems, no amount of knowledge concerning their initial conditions would be enough to allow Laplace's demon to determine all its future states. If that is the case, that is, if systems exist in which it is in principle impossible to determine exhaustively their initial conditions to an infinite degree of accuracy, and if, in addition, such systems are extremely sensitive to these initial conditions, then their evolution will be objectively asymmetrical with respect to time. In other words, if ''for certain types of systems an infinitely precise determination of initial conditions leads to a self-contradictory procedure'' (Prigogine, 1984, p. 262) because the initial conditions for such systems are inherently undeterminable, then an ineradicable element of instability, randomness and irreversibility determines their evolution.

According to Prigogine, an ''entropy barrier'' acts as a selection principle, requiring an infinite information content for those kinds of initial distributions lending themselves to deterministic temporal reversibility. Such an entropy barrier prohibits the interchangeability of temporal vectors: ''In other words, the second law becomes a selection principle of initial conditions. Only initial conditions that go to equilibrium in the future are retained'' (Prigogine, 1984, p. 276), thereby making temporal asymmetry a primitive axiom of our universe. Furthermore, according to Prigogine a microscopic arrow of time is not the product of systemic instability and randomness. In fact, the relation of causality goes the other way, irreversibility constituting the condition of possibility of dynamical instability: ''Intrinsic irreversibility is the strongest property: it implies randomness and instability'' (Prigogine, 1984, p. 276).

https://doi.org/10.1177/039219219003815102 Published online by Cambridge University Press

How, then, are we to reconcile Griffin and Prigogine's theory of inherent temporal polarity with Fraser's convinction that an arrow of time only emerges with the biotemporal *umwelt*? I think that Paul Davies suggests a possible solution. Davies distinguishes between complete reductionism, the idea that "there are no emergent phenomena, that ultimately all physical processes can be reduced to the behaviour of elementary particles (or fields) in interaction" (Davies, 1988, p. 139) and uncaused creativity, a view of emergence that assumes that "new levels of organization (e.g. living matter) are not ... caused or determined in any way, either by the underlying levels or anything else. They represent true novelty" (Davies, 1988, p. 140). Of course, neither Griffin nor Fraser would see themselves in the preceding descriptions. Yet, regarding time, I believe that Griffin and Prigogine's position is reductionist and Fraser's an example of uncaused creativity.

On the one hand, by postulating that temporal asymmetry is a primitive dimension of being, process philosophy must define the human subjective sense of time as merely a version of an underlying arrow of time. On the other hand, although Fraser's cosmology of time is aggressively evolutionary, it nevertheless requires that an arrow of time emerge full-blown, like Athena from the head of Zeus, with the leap into biotemporality. Although for Fraser time evolves, temporal asymmetry does not; on the contrary, an arrow of time is a genuinely discontinuous event with no precedent.

It could be that the irreconcilability of these two views, the reductionist always already and the radically emergent, is a level-specific conflict that can only be resolved at a higher level of analysis. I believe that the third possibility suggested by Davies—a view that conjoins reductionist principles with emergent self-organization, is precisely such an upper-level solution: "If we accept that there exists a propensity in nature for matter and energy to undergo spontaneous transitions into new states of higher organizational complexity, and that the existence of these states is not fully explained or predicted by lower level laws and entities, nor do they 'just happen' to arise for no particular reason, then it is necessary to find some physical principles additional to the lower level laws to explain them" (Davies, 1988, p. 142). Davies proposes that the tendency of far-from-equilibrium, open, non-linear systems with feedback to undergo spontaneous global leaps of organization can accommodate the requirements of evolution with those of discontinuous emergence. In a similar vein, I would like to suggest that temporal asymmetry is a feature of all integrative levels, but that, like time itself, it has evolved in an essentially chaotic way consonant with the fundamental institutions of Prigogine and Davies concerning self-organization.

FRACTAL TIME

Frederick Turner (1985) argues that the universe may be the result of a bottleneck:

> The universe is the result of a scheduling problem. Everything that can happen, including nothing at all, happens as fast as it can. But logically certain things can only happen after other things. Hence periodicities occur, and events that depend upon the existence of periodicities. Room must be found in time to close-pack these events as efficiently as possible. The world is a branching flow-chart that regulates itself. The tree of life. (Turner, 1985, p. 49)

Keeping to the spirit of Turner's idea, I propose to modify it minimally in order to suggest a fractal theory of time. Wiley and Brooks claim that evolution is characterized by an ever increasing difference between maximum possible entropy and actual entropy. Analogously, I hypothesize that the evolution of time is fueled by the difference between the amount of time necessary to exchange information and the amount of time available to accomplish this exchange. If an evolutionary *umwelt* is the totality of information available at a given level of complexity, then there will always be a misfit between the maximum speed with which information can flow and the actual time required for such processing. Normally, accommodations can be made, and a relative state of equilibrium can be maintained. Such states are equivalent to Fraser's *umwelt*. However, as Fraser himself points out, certain conflicts invariably arise that push an integrative level out of equilibrium. I believe that such conflicts are actually both the result and the product of nature's tendency to spontaneously self-organize. In other words, there is a feedback relationship between

https://doi.org/10.1177/039219219003815102 Published online by Cambridge University Press

self-organization and disequilibrium: small asymmetries are able to expand asymptotically kicking systems into a far-from-equilibrium state which itself can create further asymmetries. Evolution may be nothing more than nature expanding itself discontinuously so that it may have more time to process more information.

Fraser is quite correct in claiming that the evolution of time expands the amount of world. He is also correct in arguing that time evolves into increasingly more complex temporalities. I differ from Fraser, however, when he asserts that temporal asymmetry is an emergent feature of the biotemporal *umwelt*. Instead, I propose that an arrow of time has always existed, but that it has evolved from a state of near nullity in the atemporal *umwelt* to a sharply defined vector in the nootemporal *umwelt*.

The evolution of time, therefore, would be the evolution of temporal asymmetry. Fraser's chronons, objects with zero rest-mass and distances of the order of the Planck length, are genuinely atemporal. However their integrative level can be pushed into a far-from-equilibrium state introducing enough of a seed of temporal asymmetry into the atemporal *umwelt* to enable the emergence of prototemporal temporality. Although it is generally assumed that no arrow of time can be said to exist in the prototemporal *umwelt*—"Quantum theory denies all meaning to the concepts of 'before' and 'after' in the world of the very small" (Wheeler, 1988, p. 13)— there is reason to believe that even in the prototemporal integrative level a weak and admittedly fuzzy arrow of time exists. For example, Roger Penrose has speculated that "the initial smoothness of the universe ought to emerge from a time-asymmetric fundamental law ... Penrose points to the existence of certain exotic particle physics processes that display a weak violation of time reversal symmetry, indicating that at some deep level the laws of physics are not exactly reversible" (Davies, 1988, p. 153).

I suspect that an element of time irreversibility is precisely what prompted the initially featureless early universe to begin its evolution. An intriguing theory in this regard is the inflationary scenario, which posits a time reversible initial smoothness reminiscent of Fraser's atemporal *umwelt* that subsequently undergoes a global and irreversible loss of symmetry:

> During the inflationary phase the universe was in a condition of perfect symmetry. It consisted of precisely homogeneous and isotropic empty space. Moreover, because the expansion rate was precisely uniform, one moment of time was indistinguishable from another. In other words, the universe was symmetric under time reversal and time translation. It had 'being' but no 'becoming'. The end of inflation was the first great symmetry break: featureless empty space suddenly became inhabited by myriads of particles, representing a colossal increase in entropy. It was a strongly irreversible step, that imprinted an arrow of time on the universe which survives to this day. (Davies, 1988, p. 129)

The end of inflation may have been a monumental feat of self-organization, when the homogeneous universe suddenly increased its total potential entropy thereby creating a difference between maximum potential entropy and realized entropy. According to the Wiley and Brooks hypothesis, an expanding phase space in which maximum potential entropy increases faster than actual entropy inevitably produces time asymmetry. Therefore, the expanding phase space of the atemporal *umwelt* might have been the seed for the weak temporal polarity of the prototemporal *umwelt*. Analogously, the expansion of the prototemporal *umwelt*'s phase space may have engendered the rather more pronounced thermodynamic arrow of time characteristic of the eotemporal *umwelt*. If this scenario is accurate, Fraser's biotemporal present was indeed a massively discontinuous intensification of temporal asymmetry, but it was not its emergence *ex nihilo*. On the contrary, biotemporal temporal anisotropy would be simply one moment in the evolution of greater and greater temporal asymmetry.

The universe's expanding phase space, the difference between totality of information potentially available for processing at a given level of complexity and the amount of information that the level's constraints allow, creates the entropy differential that is a level specific temporal anisotropy. Of course, not all systems within a given *umwelt* need to display its characteristic arrow of time. Even nootemporal human beings experience eotemporal pure succession or prototemporal probabilistic succession. In fact, the time reversible equations of classical physics are a kind of description of eotemporality in equilibrium. However, I believe that each *umwelt* contains processes that display an arrow ot time, from the faintest asymmetry inhabiting the atemporal to the

https://doi.org/10.1177/039219219003815102 Published online by Cambridge University Press

pronounced temporal asymmetry of the nootemporal. Furthermore, just as an arrow of time becomes more pronounced and clearly delineated as time evolves, so does the relative importance of anisotropic temporal events. Until the biotemporal *umwelt*, the arrow of time is both weak and limited in scope, so it plays a relatively minor part in the functioning of systems. With biotemporality, and especially with nootemporality, temporal asymmetry becomes increasingly important, so much so that a sharp distinction between past and future is less an incidental characteristic of human beings than definitive of what it means to be human.

I believe that the far-from-equilibrium structures described by Wiley and Brooks suggest an explanation of the mechanism underlying the evolution of time into more complex temporalities with increasingly better defined arrows of time. If Turner's distinction between nature's desire to do things as fast as possible and the scheduling problem inherent to the necessity of following certain sequences is mapped onto the Wiley and Brooks model, then maximum speed would be analogous to maximum potential entropy and the need to adopt certain sequences would be analogous to actual or observed entropy. In other words, any system must experience the constraint of the non-identity between the possibility of following all possible paths to an end and that of following only those allowed by the system.

There is an element of tragedy in evolution, a version of the quantum mechanical idea of collapsing the wave function. Systems are always slower than they might be if every possible temporal combination allowable in principle in a given *umwelt* were to be realized; yet, it is because of this tragic choice that something gets accomplished at all. A system in maximum temporal entropy would be rarified potential and little else. Like a thoroughly deconstructed world, it would spin so fast and in so many directions that the end result would be a strange barrenness.

Since a given *umwelt* must allow for the making of choices if it is to do anything, and since choice implies that the system must always run more slowly than it could if it were to devolve into pure possibility, then it follows that a given system or *umwelt* will always run a bit behind schedule. Derrida's (1982) notion of primordial delay is very useful here, since I think it accurately describes the simple idea that the cost of preventing a system from disintegrating into maximum potential entropy is a discrepancy between what can be done and what needs to be done. Far-from-equilibrium systems are always a bit slow: their phase space is characterized by the difference between the need to work as fast as possible and the tragic necessity of choosing actual temporal configurations. I believe that when this situation becomes exacerbated, the conditions are right for a global leap of self organization, increasing the temporal phase space of the system.

Global and discontinuous expansions of a system's temporal phase space is intuitively represented as a kind of explosion. Indeed, the evolution of the universe is normally pictured as physical expansion following an explosive Big Bang. As long as we realize that such expansion is in fact a metaphor describing the increasing complexification of time, it is a useful visual representation of evolution. However, I would like to suggest that it is possible to view evolution inversely, as increasing contraction into more and more complex configuration. I suspect that a system creates more time for itself by imploding, that is by creating greater temporal depth. Needing to accomplish an infinite number of tasks infinitely fast, yet restricted to a finite temporality, time behaves like phase space when it is stretched and folded to accommodate exponential expansion in a finite space:

> The key to understanding chaotic behavior lies in understanding a simple stretching and folding operation, which takes place in the state space. Exponential divergence is a local feature: because attractors have finite size, two orbits on a chaotic attractor cannot diverge exponentially forever. Consequently the attractor must fold over onto itself. ... The process of stretching and folding happens repeatedly, creating folds within folds *ad infinitum*. A chaotic attractor is, in other words, a fractal: an object that reveals more detail as it is increasingly magnified. (Crutchfield, 1986, p. 51).

I imagine the evolution of time to be a similar kind of stretching and folding. If that were the case, then Fraser's temporal *umwelts* would be increasingly complex because they would display greater fractal depth, that is, they would be a palimpsest of more and more complex temporalities. The more complex a temporality, the better defined is its arrow of time, and the more different means it has at its disposal to do things. For example, compare the primitive and deterministic temporality of a paramecium's nervous system to the incredibly complex way in which the human brain juggles a huge number of temporalities. However, just as Fraser suggests that the price paid for resolution of lower-level conflicts at an upper level is the emergence of new conflicts that are themselves unresolvable at the upper level, the price for an increase in scheduling possibilities is an ever increasing number of kinds of work that can be done. In other words, as Wiley and Brooks claim, the evolution of the phase space of a far-from-equilibrium system will always mean that maximum potential entropy increases faster than actual entropy. Although in the following citation Wiley and Brooks are discussing space, I think that an analogous argument can be made for time:

> For example, cosmological models suggest that the universe expands faster than the matter in the universe can distribute itself. The reason for the lag is gravitational effects that slow the expansion of matter. As a result, there is local clumpiness of expanding matter within expanding surroundings. The expanding phase space means that the entropy maximum (S max) for the system is increasing through time. The expansion of matter and dissipation of energy from the clumped matter indicate that entropy (S) is increasing as result of work being done. The ordering of the universe indicates that Smax is increasing more than S, so the accumulation of physical order is due not to local entropy decreases but to constraints slowing the increase in entropy. In other words, the system is constantly moving towards entropy maximum, but Smax is receding from the system faster than the system expands towards it. (Wiley and Brooks, 1988, pp. 58-59).

That is, as the universe creates more ingenious ways to do work, it simultaneously creates more work for it to do. The tragedy of tragedy is that its resolution is simply the beginning of even greater tragedy whose pathos is unimaginable at the level of the original tragedy.

A kind of primordial delay selects for the folding of time into itself, creating complexity, depth and increasing asymmetry. This new state of complexity solves the scheduling problem at the original level, only to find itself in ingenious new bottlenecks. As time becomes more distinctly asymmetric, more space is created for remembered work and projected work. Furthermore, entirely new temporal technologies emerge, such as parallel and distributed processing, ritual and fiction. However, even as they allow for the exponential increase of information processing technologies, they also create new dimensions of potential temporal speed against which any actual speed is deemed slow. Time's depth, the infolding of its phase space to create the intricate and beautiful filigree of nested temporalities described by Fraser is itself the most asymmetrical temporality imaginable. The ultimate arrow of time is time's fractal depth, the history of its tragic resistance those limits which had, at a previous level, just set it free.

Alexander J. Argyros
(*The University of Texas at Dallas*)

BIBLIOGRAPHY

BROOKS, DANIEL R. and WILEY, E.O. (1988), *Evolution as Entropy*, Chicago, The University of Chicago Press.
CRUTCHFIELD, JAMES P., FARMER, J. DOYNE, PACKARD, NORMAN H., and SHAW, ROBERT S., "Chaos", *Scientific American*, Volume 255, Number 6, December 1986.
DAVIES, PAUL (1983), *God and the New Physics,* New York, Touchstone Books.
— (1988), *The Cosmic Blueprint*, New York, Simon and Schuster.
DERRIDA, JACQUES (1982), *Margins of Philosophy*, Chicago, The University of Chicago Press.
EDDINGTON, A. (1928), *The Nature of the Physical World,* Cambridge, Macmillan.
FRASER, J.T. (1978), *Time as Conflict,* Basel and Stuttgart, Birkhauser Verlag.
— (1987), *Time the Familiar Stranger*, Amherst, The University of Massachusets Press.
GARDNER, MARTIN (1979), *The Ambidextrous Universe: Mirror Asymmetry and Time-Reversed Worlds*, New York, Charles Scribner's Sons.
GRIFFIN, DAVID RAY, "Time and the Fallacy of Misplaced Concreteness", in GRIFFIN, DAVID RAY (ed.), (1986), *Physics and the Ultimate Significance of Time: Bohm, Prigogine, and Process Philosophy*, Albany, State University of New York Press.
HAWKING, STEPHEN W. (1988), *A Brief History of Time*, New York, Bantam Books.
LAYZER, D. (1975), "The Arrow of Time", *Scientific American*, 233:56-69.

PRIGOGINE, ILYA and STENGERS, ISABELLE (1984), *Order Out of Chaos*, New York, Bantam Books.

PRIGOGINE, ILYA and ALLEN, P.M. (1986), *The Challenge of Complexity. Self Organizing and Dissipative Structures*, Austin, University of Texas Press.

TURNER, FREDERICK (1985), *Natural Classicism*, New York, Paragon House.

WHEELER, JOHN ARCHIBALD, "World as System Self-Synthesized by Quantum Networking", *IBM J. Res. Develop.*, Vol. 32, No. 1, January 1988.