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Continuity, Time, and Order

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Western intellectual history has embraced two incompatible metaphysical doctrines: first, the doctrine of atomism (as a representative of continuity, or the Great Chain of Being, or the Plenum universe) and equally, the doctrine of atomism (as the thesis of ultimate *dis*continuity of all existants). Our approach to understanding — taking things to pieces to discern their essential parts and their workings — is blatently contradictory, with the universe being continuously discontinuous (atoms as smallest bits) or vice versa (a continuously filled plenum). We have tacked between incompatible opposites. The second doctrinal opposition concerns time — first the Greek view, as succession or endurance through events, then time as absolute in Newtonian mechanics. After the pendulum swing following quantum theory, all that remains of Newtonian absolutism is the hyphenation, from Einstein, of space–time, and a tendency to regard time-as-endurance as disposible — solely observer relative, secondary or merely psychological, rather than ontological. Science sees time only as succession. Contemporary science finds no continuity in the universe, and time only appears as succession in relative inertial frames of observers. Thus the problem of the order of ourselves and the universe becomes more problematic (and a solution more necessary) than usually acknowledged — especially with regard to the nervous system (cognition) and agency. Since order is existence, which is endurance in living systems, order must become a temporal rather than a spatial concept. Time is an absolute (absolutely necessary) only in the order of epistemology, not in the order of physical theory.

Keywords: continuity, time, dimensionality

"Why does the universe unfold its successive states with a velocity which, in regard to my consciousness, is a veritable absolute? Why with this particular velocity rather than any other? Why not with an infinite velocity? If the future is bound to *succeed* the present instead of being given along side of it, it is because the future is not altogether determined at the present moment…. It is because there is unceasingly being created in it … something unforeseeable and new."

Creative Evolution
Henri Bergson, 1911, p. 369

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Long ago Bergson saw that unless the universe is *not* continuous in the sense of co-occurrence, of everything determined from initial conditions entirely covered by inexorable laws of nature, there could be nothing new: no knowledge, no novel thought or behavior, nothing unanticipated or unforseen at all. But our "scientific" approach has until recently been built upon the myth of continuity.

Continuity has been a presupposition of reasoning about physical and mathematical domains for centuries. So ingrained in what Sellars (1963) called the manifest image of our world, it is rarely explicitly discussed (like its companion doctrine of the Plenum universe). It has become a tacit background assumption that has faded into an ultimate presupposition, no longer seen, never discussed, not even mentioned. Leibniz provided a rare explicit discussion of what he called the Principle of Continuity, and his (and rival Newton's) development of calculus and belief in metaphysical determinism stems from this conception of continuity. Consider first these remarks about the *determinism* of the Principle of Sufficient Reason:

> Everything is interconnected in the universe by virtue of metaphysical reasons so that *the present is always pregnant with the future*, and no given state is explicable naturally without reference to its immediately preceding state. If this be denied, the world will have hiatuses which would upset The Principle of Sufficient Reason and will compel recourse to miracles or to pure chance in the explanation of phenomena. (translated by Weiner, 1951, p. 185)

Now consider *continuity*:

> Everything in that science (geometry) is perfectly interconnected ... no single instance can be adduced of any property suddenly vanishing or arising without the possibility of our determining the intermediate transition, the points of inflection and singular points, with which to render the change explicable, so that an algebraic equation which represents one state exactly virtually represents all the other states which may properly occur in the same subject. The universality of this principle in geometry soon informed me that it could not fail to apply also to physics, since I see that in order for there to be any regularity and order in Nature, the physical must be constantly in harmony with the geometrical, and that the contrary would happen if wherever geometry requires some continuation physics would allow a sudden interruption. (ibid., p. 185)

The result of this "interconnection" is the Plenum universe — where everything continually merges into everything else and everything that can exist does of necessity exist (so that all potential empty spaces are filled). This is the great chain of being: "It is necessary that all the orders of natural being form but a single chain in which different kinds like so many links clasp one another so firmly that it is impossible for the senses and imagination to fix the exact point where one begins or ends" (ibid., p. 187).

For the mind of the seventeenth century, continuity was present everywhere one looked, from advanced mathematics to scientific discoveries and theories. The manifest image of common sense retains that outlook today. It has even reentered physics through a back door, in the quantum problem of entanglement, which has stretched continuity over "action at a distance." The problem, as the epigraph from Bergson shows, is that in continuity there is no possibility of novelty or freedom. In the eighteenth century David Hume destroyed that "principle" of *sufficient* reason by using reason to whittle down the false claims of indubitable rationality. Empirically, our experience does not disclose continuity anywhere — only the (often apparently invariable) succession of events. We see neither causality nor continuity "out there" in reality, only (now making the transition to Kant) finding it as a category of our thinking *about* reality. From this latter perspective we have developed the conception of "laws of nature" as inexorable, applying every-where, every-when, independent of an observer.

What is the Reference to Which Continuity Applies?

What is continuous (regarded as exhibiting continuity)? All traditional enduring "things," like books, the tables they are on, our homes, furniture, machines, all the myriad items of every day existence manifest image life including our cognition and bodies. Those are all particulars. More general categories are regarded as continuous even though there is some "change" present over time: I am the same old curmudgeon of 30 years ago (so I am often told), biological species are the "same" species even though there have been changes over millenia, the north magnetic pole is the same even though it has moved around, and so on. Processes that exhibit (or undergo) more rapid changes, sufficient to negate or call into question that sameness, are regarded as discontinuous. These present more traditional "philosophical" (i.e., debatable and definitional) issues such as whether that flickering flame is the same "one" that it was 15 minutes ago, or to what extent an old man is the same as his younger self. Indeed "self" is an enduring issue on this point.

Continuity and Time

Such discussions center upon *reference,* and ask if this XYZ refers to an "identical" XYZ *of some prior time*. This is how time becomes bound to continuity and discontinuity. Can you step into the "same" river twice, or is it not possible to step into a "same" river even once? Such questions are resolved by explicating the "sameness" involved, primarily by William James's very Leibnizian criterion that a difference, to be a difference, must *make* a difference. The nature of a continuant (to use C. D. Broad's [1949] essay title) is the same (or continuous) if it remains the "same" in the specified essential sense, and discontinuous and thus not a continuant if it does not. Our theories of subsistent "things" specify dynamical

processes that identify sameness in apparent diversity. The river is "continuous," so you can step in twice. Conversely, theories of discontinuity identify different processes in instances of apparent sameness: you can't even step into the "same" river once. So continuity means relatively unchanging through a given time period. This becomes interesting when we recall that communication theory identifies information with bits which are specified in terms of differences. When does a "bit" represent sameness or difference? Here semantic ambiguity enters in, and that is beyond syntactic information theory. Actual continuity would provide no bits at all, no information, no meaning, nor any possibility of knowledge. (There could be no distinction between the subject who has knowledge and the object which is known.) Pure syntax may appear to be continuous, but when semantics enters, it differientiates and then differientates indefinitely more in recursive fashion until continuity disappears into a purely abstract conceptual entity. Empirical continuity disappears, leaving only the timeless abstract entity in the specious present moment in thought.

The Continuity of Semantic Meaning

All meaning is both continuous and time invariant. Seemingly fixed meanings change over time (as with advances in scientific theory), when we actually propose and then employ new meanings for old referents, or redefinitions of what those referents consisted in (that flickering flame used to show phlogiston being given off by the burning substance). Now a flame is an exhibition of the process of rapid oxidation, and in consequence the meaning of "burning" has, despite continuity of both term and referent, changed into something new. If this "oxidation" theory is supplanted (as by a quantum account dispensing with the concept altogether) the older meaning still remains fixed forever in the prior theory. Meanings change with changes in dynamical or rate dependent theories, but they always become new meanings. The "old" meaning is always fixed timelessly within its given theory.

Whatever is in the specious present is fixed and unchanging for the period of its existence. Specious present instants (instant is the correct term, stemming from instantiation) succeed one another when their fixed meanings change into new, equally fixed meanings. Without change the specious present moment would be eternal. With the presence of changes we are the creatures that we are. Pioneer neurophysiologist C. S. Sherrington noted this in 1906:

> The mental "now" is a unity, because whatever its items they can join to one significant pattern, a serial "now." To think of time as unifying the experience of the moment makes of time an integrator of the mind; but the unifying by the mind of its experience of the moment can no less be taken as an integration. There are … psychological figures [as in the descending staircase versus upward cornice molding deep structurally ambiguous figure], called equivocal because at one moment they look one thing, at another another. While looked at their

> "meaning" unaccountably changes; what is being looked at as a set of steps suddenly without warning becomes an overhanging cornice. But it is always the one or the other wholly. (1906/1963, pp. 216–217)

The time invariant (meaning time independent) domain of meaning is one thing, the rate-dependent dynamics of physical–spatial processes is another. Meaning is timeless; in contrast, rate-dependent physical processes have no meaning at all — unless a subject or agent is there to provide it in the rate-independent realm.

The Grain Objection Once Again

Consider the usual mind–body problems — reflect upon Sellars' famous grain objection to the traditional problem of reference proposed by the neural identity theory of mind. The objection is that since meaning is a denizen of the atemporal or specious present phase of existence it is an empirical question whether a given meaning in that timeless conception is or is not to be *theoretically identified* with any given dynamical process. Since all rate-dependent processes (and their theories) are discrete or discontinuous, it is clear why attempts to refute the grain objection are forced to propose that the observable "gappiness" or discontinuity of phenomenal experience is an indication of "identity" between actual experience and discrete (or discontinuous) neural processes. The next step proposes a critical fusion frequency account to say that the "appearance" (imagine identity theorists biting their tongues not to say "the illusion") of continuity is a result of exceeding that, or a similar, "threshold" effect. This proposes there is somehow an integration over time of specious present moments that, above the CFF (critical fusion frequency is usually defined as the frequency at which a flickering light is seen as continuous), give us the "continuous" existence we experience. Unnoticed by the materialist identity proponents, this is fundamentally a doctrine of emergence for continuity. Also note that there is no physical (dynamic) theory of why any such "integration" should yield continuity in perception — the CFF is a functional, not a physical, concept.

The grain objection does not dispute discontinuous experience, nor its basis in discontinuous neural processes. To repeat, there is nothing in the universe that is actually continuous within the rate-dependent realm: no "physical process" is continuous even down to the quantum level of analysis, and certainly down to the so-called Planck level for time or space, the limit of measurement beyond which we can never know.

The grain objection is that the meaning of, to use the original example, a pink ice cube, is continuous in the sense that a pink expanse simply cannot be identified, either referentially or semantically (intensionally, etc.), with any possible discrete process at all. Timeless fixed meaning cannot be discontinuous in either sense or reference. Thus the grain objection to any neural process identity theory

is that no such identification can exist. Phenomenally present pink cannot be the sort of thing that is not continuous. Tenseless (and timeless) contents of the rate-independent mental realm can never be identical to discontinuous dynamic events in the rate-dependent realm. One cannot invoke the rhythm of the mind (the temporal patterning of neural activity) as an alternative description of the intrinsically timeless specious present. Rate-independent versus rate-dependent remains an ultimate dualism. Adequate accounts of reality must have both (Pattee 2012; Weimer 2021, 2022), and must clearly locate continuity only within the rate-independent realm of cognition. The grain objection is thus an example of the unbridgeable gulf between the rate-dependent and rate-independent realms, and the separation between the physical and the functional.

If Rate-Dependent Continuity Existed, It Would Be Incompatible with Evolution

Any actually continuous dynamical entity could never have emergent properties or states of existence. It would, by conceptual necessity, be static and fixed forever, with no discernible initial or terminal states. The information which that "difference" would constitute could never (to use William James's turn of phrase) *make* a difference and thus could not have evolved, nor support future evolution. That point was a focal emphasis of Bergson's 1911 book *Creative Evolution*. As he said in the epigraph "the future is not altogether determined at the present moment." Evolution *presupposes* that continuity — with the present containing all the past and all the future (usually stated in the sexual metaphor of the past "being pregnant with" the future) — *cannot and does not* in fact exist.

Reproduction Requires Discontinuity

Not only is continuity incompatible with evolution, it also prohibits reproduction. In either sexual or asexual reproduction something *must* be split off from, be rendered discontinuous with respect to, an earlier or parent generation. The offspring, while preserving *most* traits and properties of the parent, is *never* identical to it. That is what it *means to evolve*. Reproduction is only *approximately* continuous. If it were continuous (all cells duplicated exactly) in all respects, evolutionary change or development could never occur; all individuals would be identical to all others (thus not "individual" at all), and would always be. There would never have been a need for evolution, and none could have arisen.

Learning and Adaptation

Evolution presupposes discrete (but *partly* repeatable and *relatively* constant) classes of events. Similarly, learning presupposes variable but relatively constant events. Learning is a mechanism that allows an organism to profit from variability

in events during its lifetime. It allows increased adaptation to an econiche by harnessing the nervous system's ability to classify and reclassify events. It does this by selective retention of patterns of behavior that initially arose from blind response variation. But blind variation and selective retention could not arise in either a universe of actual continuity or one of complete random (chaotic, in the manifest image sense) or happenstance variability. There could be no selective retention of adaptive responses or genetic changes in a genuinely random environment: no response would be adaptive in comparison to any other; no mutation would aid survival. That is why evolution involves *blind* but *never* random variation. If the universe is evolving there can be no continuity in the dynamical events. Genuine continuity exists only in the timeless abstract conceptual realm, as an ideal type with no empirical content, as in timeless, locationless abstract concepts such as justice, truth, beauty, and for that matter, eternity.

Both Physically and Conceptual–Mathematical Infinities Depend Upon Recursion, Not Continuity

Recursive operations create seemingly continuous series. But the only infinities we know are *not* continuous. Consider the power of the continuum. Since the time of Cantor it has been known that for any line, it is always possible to add another "point" between any two points of it. Thus the line is infinite with respect to the total number of points which it contains. But this infinity is purchased at the cost of denying any actual continuity to the line, which has become merely an infinitude of discrete points lying (or sitting or kneeling or dancing) on what we draw or fabricate. Linguistic productivity is the same process of iteration. Novel sentences, as meaningful utterances, are made up by applying recursive processes to generate from a finite vocabulary list an indefinitely extended domain of meanings. All physically infinite totalities result from recursive operations. Iteration gives us our only taste of the infinite. Exactly the same holds for the entire conceptual realm: the "infinite" is indefinitely recursively iterated.

Ideal Types Versus Statistical "Determinations"

There are no straight lines in dynamical nature. "Straight" is a conceptual abstraction that is found to only be approximated in the physically real empirical realm. Examined in the light of quantum physics, the coherent light beam, that straightest of lines, is actually composed of discrete and discontinuous packets of the light quantum (as Einstein called it), now called photons. Everything in reality is a statistical approximation: regularities are determinate but not deterministic as that term was traditionally interpreted. The usual social sciences concepts, qua idealizations, fail to reflect this. The economist's concept of equilibrium doesn't and cannot exist in any real market order. Nevertheless it is a useful

theoretical simplification or abstraction, but only as a conceptual limit point. In other areas, such as vaccination in medicine, we are well aware of the statistical nature of the concepts involved. What we should do in all life sciences is regard all empirical continuities and seeming certainties as at best provisionally and *statistically* realized.

Here we may parenthetically note that this has import for the now long abandoned "great age of learning theory" controversies from the 1930s to the 1960s. One might consider another look at the Guthrie–Estes approach, with its emphasis on learning being the complete conditioning of the instant S–R connections on each individual trial, and the slow or gradual learning curve graph as a reflection not of that all-or-none conditioning but rather of the immense variation in the "momentary" snippets being quite different from trial to trial, so that considerable time is required to "build up" the statistical–probabilistic linkage that the experimenter regards as "learning."

Back to Epistemology: It Takes Two to Tango

Knowledge requires adequate accounts of both the rate-independent (or timeless) conceptual–semantic domain and the rate-dependent (dynamics) functioning of the nervous system for the task of understanding human beings and the universe they live in. This is an essential and inescapable complementarity. For psychology and epistemology this means that we must have both a structural analysis of the processes by which cognition occurs (a syntax of action) and also a complementary functional analysis of the symbolic entities that constitute our conceptual mental realms (a semantics of life and the universe it inhabits). If we have only one alone we will wind up with a meaningless, therefore purely physical syntax (if we have only a "hard" psychophysiology), or we will have a hopelessly ambiguous, and equally meaningless, circularly defined functional semantics (as in Gibsonian or Skinnerian accounts). As Pattee (2013) outlined, symbols and meaning must satisfy certain conditions (constraints). First, what we call information is the result of local structural constraints acting upon dynamic processes that obey physical laws. Second, the storage and communication of information has both logical and empirical–statistical limits. Third, the constraints that execute information in biological systems are subject to physical restrictions. Fourth, autonomous agents (but not necessarily conscious ones) must *interpret* all information vehicles. Fifth, these agents must decide or *choose* what separates the information vehicle from what that information refers to. This epistemic cut or closure that agents make, as Pattee termed it, is what distinguishes symbol from matter, information from law, and the living from the inanimate. All this is involved in the rate-independent versus rate-dependent distinction that is part of our existential situation.

Time and the World Order

With the exception of one past period in science, there has been remarkable agreement that time is a subjective (more correctly, individually perceived) phenomenon. The Greeks recognized duration as the occurrence of (a series of) successive events and did not discuss time as an independent concept in addition to, or as independent from, successive "pictures" of the flow of the events themselves. Without denying the reality of time from the standpoint of human experience, classic thinkers did not attribute it to an objective or *independent* aspect of non-mental reality. That changed with Isaac Newton. Newton made progress by ignoring problems. For his mechanics to work Newton made time an absolute — part of the framework or container in which everything occurs within space and time. Time for Newton was analogous to the lumineriferous ether: an indispensable component of the "physical" framework in which everything exists. Newton's container of space and time dominated physical theory until Einstein's special and general theories of relativity overthrew it early in the twentieth century, and it was buried entirely in the subsequent quantum revolution.

The concept of the quantum occasioned a return to the "ancient" view of time as the succession of events in the hyphenated space and time manifold, and due to the relativity of inertial frameworks, it is clear that there is no meaningful sense of an absolute time any more than there is for an absolute container space (as Hume emphasized in the *Treatise*). Dynamical laws "of nature" allow events to go "forwards" or "backwards" along the time dimension, and assign no privilege or priority to any "now" in time (nor to any "here" in space). Our subject-of-conceptual-activity notions of here and now are not found in physical law and not allowed in physical theory. Such notions are among the constraints called boundary and initial conditions, and from the standpoint of physical theory are outside any laws of nature, simply frozen accidents due to our present position in the universe, our momentary relative inertial framework in the space–time "manifold."

That relegates study of time to psychology (for our experience thereof), and the domains of history (such as evolutionary biology, geology, paleontology and anthropology, to say nothing of cosmology). But what about the arrow of time, which appears as a fact to be explained about the empirical world? Why is time unidirectional? And why does it appear to be continuous? Apparently because of the second law of thermodynamics. Time occurs with changes in entropy. Time "flows" with the change from more order to less order. From *our* perspective the "past" appears as more ordered. The fixed forever, etched-in-stone past is maximally ordered, lower in entropy, than the amorphous (higher entropy) unknown future. Psychological time thus has a *perspectival* basis that is the opposite of physics — we make the entropy *of the past* special and complete from *our viewpoint*. Time has a "relativity of inertial frameworks" analogous to space. This directionality is only known to exist for agency — it requires a subject of conceptual

activity who "undergoes" time as a unidirectional flow, not leaving undetermined the question of whether time would be reversible if the universe contained only things obeying the inexorable and time reversible "laws" of nature. Our *theory* of the inexorability of laws is all that says it would be reversible. Like the here and now, our *experience* of inexorably directed flow from past to future is outside of a "purely" physical account of reality.

Time is discrete in the physical (quantum) realm. Remember, there are no continuous things in observable reality: time has a "Planck length" lower or building block boundary just like everything else. Our perceived time is built up from those discrete building blocks. Time appears to us to be continuous (or a flow) only because of the CFF effect of our nervous system functioning. This point was discussed by Bergson (1911) in *Creative Evolution.* He treated it on the then brand new analogy of the cinematographical method. Indeed cinematography (or "moving" pictures) was the first real (empirical) demonstration of the CFF in perception, and it is fundamental to our understanding of the integrative capacity of neural functioning. All aspects of neural activity have one or another frequency past which what is represented by the activity (in whatever modality it occurs) is fused into an apparently continuous flow to the percipient subject. Note that this is an empirical *description,* not an explanation. Time enters into the mammalian nervous system with the orienting response, the basic act of classification of thing-kinds. (Since it occurs at the very beginning it is not surprising that brain stem emotionality is so large a component of our perception of time.) At first discrete and granular, time becomes experientially continuous when that fusion frequency is exceeded. Humans vary in this regard. Leonardo must have had a much higher CFF than mere "mortals," because he could, with no aids, see that birds fold their wings back when in flight, and knew how a horse's legs went in a gallop, whereas art historians find no nineteenth century artist ever managed to render a horse gallop or flying wing correctly.

Is time real? Since it is perspectival it is always agency relative — to an observer, or the observer's relative inertial frame. But granting that fact, it is as real as any empirical aspect of experience. What we know of the experience of time is knowledge by description (as the doctrine of structural realism makes clear: see Maxwell, 1968; Weimer, 1975) in one or another conceptual (theoretical) scheme, and if the theory is useful in explaining our perception of reality, it will be retained as real in our explanatory account of the manifest image even though the concept is no longer required in physical theory for understanding of the non-mental realm. An adequate theory of the subjective experience of time need have no necessary direct correspondence to the dynamical theory of events in the space–"time" manifold. Despite its hyphenation in current accounts, in physics that manifold is entirely spatial. Physics deals only with the spatial relations of its basic entities. Time is an afterthought, an added-on conceptual necessity to account for change.

Excursus: Dynamical Continuity Would Require Infinite Energy

Granting that the entire rate-dependent universe is ultimately discontinuous, what would be required for a physically continuous "subsistent" entity to exist? Imagine we wanted to create a continuously existent subatomic particle. If the fundamental forces of the universe are ultimately discontinuous, what would be required to bridge the energy gap that underlies all known processes? It would appear that creation of an enduring genuinely continuous entity would require an infinite amount of energy. The problem would be analogous to the creation of a singularity cut off from the rest of the universe (as in a black hole). This is in effect another way of stating that there are no physical infinites in the universe. All existent infinites are totalities of collections of discrete "things" that are indefinitely iterated by mathematical rules that are recursive. The infinite is a denizen of the rate-independent domain, not the rate-dependent physical one.

Excursus: Is Perception Continuous or Discrete?

Perception is both continuous and discrete. The *process* of perceiving is discontinuous, involving repeated sampling of the ambient array by the senses at a rate that is well above the critical fusion frequency, which gives us the *appearance of continuous flow* and persistent entities in perceptual experience. Thus, *functionally speaking*, perception is a continuous process that involves the pickup of "information" over time and (for organisms capable of movement) over space. The twentieth century controversy between Richard Gregory (1966, 1980) and James Gibson (1966, 1979) over whether perception is an active construction of "snippets" (Gregory) or a passive pickup of already existing information in the array (Gibson), was fundamentally misguided. It failed to distinguish the differences between the rate-independent realm of conception and semantic content and the rate-dependent realm of dynamical physiological (embodied mind) theory. Thus it engendered arguments that were constantly at cross purposes. Gregory correctly emphasized the hypothetical or conjectural nature of perception but couldn't really show how snippets of information become meaningful to the organism. Gibson correctly studied the functional or meaningful nature of perception for the organism but could never say how it actually occurred. Gibson and his phenomenalistic followers have failed to realize that the causal theory of perception must go all the way "down" to (at least) the quantum level of reality and cannot be stopped at (or re-defined as beginning with) the level of organismically relevant (meaningful) percepts. To do so is incompatible with physical theory, what we know of evolution, and what we know of the neurophysiology of perception. So the end result is that both sides ignored the truth in the other position.

Gregory did win that battle with respect to one crucial point. From the standpoint of evolution, perception is *always* hypothetical or conjectural. When an

organism perceives, it is making a conjecture. That conjecture is based upon the information available to the organism from its (inherited) evolutionary history and its individual (learned) history. Thus even the preformed or "given" affordances proposed by Gibson are evolutionary guesses (otherwise they could afford an organism nothing at all) — and like our explicit theories, they are conjectures held in check by refutations from reality when they are not adequate. Whether that guessed "information" was "picked up" in direct, unmediated fashion, or (as physiology requires) in terms of other cognitive processes intervening, is beside the point. Whatever the umwelt "affords," it must have resulted from the prior learning history of the organism as a group selected member of the species and as an individual phenotype of that species in a particular situation. That is the message of evolutionary epistemology. It is why the realist Lorenz is a pioneer of evolutionary epistemology and Gibson and the von Uexkülls, with phenomenalistic "umwelt" conceptions, are not.

A Speculation about Time

Physical science strives to reduce the number of explanatory concepts it employs. Newton equated force to the product of mass and acceleration, thereby reducing three seemingly independent physical concepts to one equation of their interrelation — effectively rendering "force" an explained concept rather than an explaining one. Similarly, Einstein "reduced" Newton's independent space and time to the hyphenated space–time concept. Should quantum gravity theory(ies) succeed, an independent force called gravity would be displaced in similar fashion. Such theorizing has led to a focus upon the properties of space–time instead of prior exclusive study of "matter" alone. Gravity is now presumed to be an aspect of space–time, not a property of "matter." In fact "matter" is in danger of being "explained" as a result of the framework in which it is found.

Analogous reasoning reduced the dimensionality of the universe by eliminating the independence of depth. The holographic model of volume has argued for the redundancy of depth by showing that all information in a volume can be specified in the totality of its two-dimensional surface. Similarly, Pribram (1971, 1977, 1996) and Di Biase (2009, 2019) have argued that the functioning of the CNS (e.g., consciousness) can be explained more adequately by the holographic model than by any other conception presently available. This puts both the traditional mental and physical realms on a par, requiring only two dimensions to describe their dynamical behavior.

Is there any way to further "reduce" our understanding of reality? How could we explain the universe and ourselves in a more "fundamental" form than the two-dimensional holographic hypothesis? How could we reductively construe space–time? Or the mental realm of cognition and awareness? Can we get to Bergson's thesis that "The flux of time is the reality itself, and the things which we study are the things which flow" (Bergson, 1911, p. 374)?

There is a hint of an answer, but it requires leaving the traditional "physical" dimensions of spatial "matter" (analogously to abandoning "matter" for its arising from time–space), and abandon the conceptual implications of our apparently continuous psychological existence. The answer is to reformulate physical theory, the biology of life, and psychology (as a life science) in terms of one primitive dimension: time. All life is historical — dynamical endurance in change — and no living process can be understood in any theory that does not account for its temporal unfolding, its derivational history. The answer is to make time primary — and thus objective reality — again. We would have to go back and take Cassirer seriously when he said "Time does not stand beside things as a physical being or force, it has no independent character of existence or action. But all combinations of things, all relations prevailing among them, go back ultimately to determination of the temporal process, to divisions of the earlier and the later, the 'now' and the 'not now'" (Cassirer, 1957, p. 162).

Continuity Is Conceptual, Not Physical

The universe is fundamentally discontinuous at the level(s) of the constituents of our manifest image objects and processes. Our closest encounter with permanence and/or continuity is in the fixed past: we ourselves, and the rate-dependent events that have *already* occurred, are frozen within time (or by the passage of time), and thus no longer are in the realm of the dynamical regularities of the rate-dependent physical realm. Only memory, in the form of the present dynamic patterns of neural activity that constitute us as enduring subjects, is capable of creating a continuous realm that is at best analogous to stages of the timeless eternal specious present moment of uninterpreted awareness. Our knowledge, as exemplified in the semantic categories of classification provided by our (natural) language(s), provides the rate-independent realm of existence. The *only* rate-independent realm of existence. There is no rate-independence in dynamical reality.

We Need a Theory of Change, Not Continuity

Understanding requires a theory of change — the dynamics — as a property of time (as a property that comes into existence as a property of time). Change must be a property of time because the traditional problem of continuity *disappeared* with the quantum picture of reality. With the aid of the rate-independent versus rate-dependent distinction (first found in von Neumann, 1966; Pattee, 2012), we see that the memory of the nervous system (stemming from the memory first instantiated in genetic coding, and later in the CNS detection of novelty) created the concept (do not say the illusion) of continuity that is independent of ourselves as subjects of conceptual activity. Continuity is real within our (rate-independent) conception; it is not "real" in quantal processes

in the non-mental world. We can echo Hume on causality here: all we find in reality-as-experienced is discrete "events," we never see either causality or continuity as ontological existents that relate those events. Change is not found in the discrete states of quantum phenomena — those states are frozen in character just as is the "less than the blink of an eye" specious present moment in awareness. Within that ultimate (analogous, for life, perhaps to the Planck length) fixed and discrete interval, neither the concept of continuity nor of discontinuity properly applies. For that matter, neither does the concept of time itself. Time comes into existence only when the transitions occur (or perhaps recur). Time is the moving from one discrete state to the next. There is no time within those states themselves. This is why we must use time as the "unknown" explainer of the "known" (molar and non-quantum realm) phenomena of movement (or succession, or unfolding, or development).

Our conceptual schemes contain terms of varying degrees of familiarity within the manifest image. We are in the business of replacing the ontology of common sense with one at the fundamentally different and far more abstract level of theoretical conjecture. In rough outline, theories "explain" laws of nature which in turn "explain" facts (themselves theoretically determined) that we encounter. There is a hierarchy of explanatory concepts with regard to conceptual dimensions. We are familiar with a picture of *levels* of explanatory concepts: theories are above or higher in explanatory relevance than laws, which are in turn higher than facts. But this is equally "unexplained explainers" being higher than "explained explainers," which are in turn above "explained non-explainers." This in turn is again also equally "unknown knowns" as more comprehensive than "known knowns," which are in turn above "known unknowns." And finally this hierarchy is "unfamiliars" that are used to explain "familiar unfamiliars" which in turn are supposed to explain "familiars." This puts time in its usual *unknown* and *unfamiliar* role: time is an unexplained explainer, which is to say an unknown known, which is also to say that for the manifest image we inhabit it is an ultimate unfamiliar.

The Hyphenation Should Be Time–Space

What we call matter is actually a property of time (or a co-occurrant property emergent with time). All that the manifest image says exists is actually a property of time. Similarly, what we call space is likewise a property of time. Existence is, for us, nothing more than endurance in the temporal dimension. What it is that endures remains an open question. Physics used to say what exists was subsistent matter. Now existence is predicated to processes in a "manifold." It is clearer with the origin of life. Here even an organism *cannot be defined* without complete specification of the derivational (temporal) history of the physical "matter" involved (see Longo, Montévil, and Kauffman, 2012; Montévil and Mossio, 2020).

Entropy Makes the World Go (Around and Every Other Way)

The "physical" time that involves clocks in its mensuration as well as the "psychological" apparent "flow" of temporal continuity we undergo is physically a result of thermodynamics. The universe as we know it exists because of the Second Law of thermodynamics. We regard entropy as a form of conservation law, analogous to the principles of symmetry and conservation that serve as constraints upon the form of acceptable physical law. Thermodynamics postulates that time arises because the "natural" state of the universe is postulated to be a flow from organization to disorder. Without entropic flow there would be no temporal flow (consider a universe at or as close as possible to absolute zero temperature everywhere — no flow of time, motion, or anything else). And our existence depends upon agency, and thus choice contingency, which requires energy degeneracy alllowing determination to be supplanted by choice enablement: enablement is causality that is not "predetermined."

We Would Not Exist If Entropic Flow To Disorder Were Deterministic

Just because the Second Law of thermodynamics *seems* to govern the universe as a whole it is not an inexorable deterministic effect in any given local region of the universe. We (and life) exist because the general or overall tendency toward disorder is compatible with localized pockets of highly organized and increasingly more complex phenomena. There is no necessitarian fate for the entire contents of the universe at all times — entropy is a *tendency* or direction *only* in global or extremely large environments. Put another way, it is the past that is frozen (and therefore has maximal order and certainty), *not the future*. Living future is open and can go any way that choice leads.

Life depends on pockets of high order (and in our mammalian cases, high complexity) occurring even though the general trend of the universe is (conjectured to be) to wind down toward entropy and absolute zero temperature. Emergence can and does occur — it is a "sometime" phenomenon of large-scale thermodynamic decay producing localized instances of higher organization and complexity (perturbations producing recurring patterns, if you like the metaphor of flow in a river "landscape"). Evolution is the prime example we are all familiar with (after all, we are its [momentarily present] product), especially as it occurs in the biology of life and the growth of knowledge (Campbell, 1974; Weimer, in press) through our cognitive processes. Our spatial dimensionality is just a frozen accident.

Time Is the Only Dynamical Process

Physical theory has heretofore assumed that the changes in so-called physical events are a property of "matter." This is evident from our concepts of determinism

and causality. The prototypic model of both was identical billiard balls hitting other billiard balls. It has been assumed that causality represents one "property" of a given billiard ball impacting another one. This mysterious property is called force. Determinism is the view that all the events in the universe run off in the manner in which they do because (some) "force" has impelled them to do so. Such assumptions have made it difficult to study, for examples, cognition and gravity. It is only recently that physics has recognized that there are fundamental things in the universe that are not in fact properties of matter. Nevertheless, current theory has gradually come to the point where the concept of gravity is a property of the space–time manifold *itself*, completely independently of whatever matter is or may exist. Cognition is now a matter of life *harnessing* physicality, as Polanyi (1969) was the first to note.

Consider change as a property of time rather than a property of matter. When we look at quantum phenomena all we see are static properties within "instants" of complexes we can do no better than call ensembles of "events." When we look, for example, at the behavior of electrons when atoms are heated all we see are a series of specious moment "timeless" and static pictures. The jump to a new orbit is conceptually instantaneous and nearly so empirically, as is implied by the concept of a quantum reality. But phenomenally there is no empirical evidence that "matter" is anything other than totally static. It is only as a property of time, of the passage of time, that we perceive any dynamical property in the world at all. Change and movement are both added *by us*. Indeed, our conception of the third dimension, depth, is entirely the result of the passage of time. This is obvious when we contemplate a holographic "film" or image — it is entirely static until we as observers (the reference beam for the holographic image pattern) move through time and give it the third dimension of depth. The theory of change has to be a theory of time, not of matter. In a timeless world nothing changes. In a world of time everything changes. Dynamics is temporal, not "spatial" or "material" or "physical."

An Old Saying Reconsidered

In the manifest image a commonplace says "Time is a way of keeping everything from happening at once." This is an interesting half-truth. Without the existence of time everything would indeed be coextensive. In that sense, and in that sense alone, if there were no time then everything would indeed "happen" co-extensively, which is to say, at once. Everything would be a matter of co-occurrence. But if time did not exist, could anything happen? No. In that situation "everything" would be static or continuous. Time would not be a meaningful concept. Given such a continuous universe, all existence would just "be," but it would not "happen." Happen is a word for some kind of temporal flow. An adequate theory of change would have to tell us how things succeed one another, and what it would mean for identifiably

separate things to coexist. Such a theory would have to be a theory of succession, explicating the lawful dynamics of how inherently static and discontinuous "things" or events exhibit what we regard as motion (i.e., differentiation or integration or change of position, etc.). The theory of time would thus tell us how things "happen" either successively or simultaneously in any given relative inertial system of the universe. In such a situation time would be a part of the fabric of the universe and not a property of matter. With regard to the problem of the dimensionality of the universe, time would be what makes the 2-D surface of the universe become three-dimensional. In such a universe time would become the reference beam for the 2-D holographic surface or film. Time as the flow of temporal becoming does indeed "force" everything not to happen at once.

Time and the Ambiguity of Physical Theory

The fundamental problem of understanding is the resolution of ambiguity. We construct our conceptual systems to disambiguate as much of the universe as possible. This is a never-ending task. We have tackled it by viewing space and "ordinary" matter as having a preferred position in our theories compared to time. Having started out with the assumption of continuity in nature (*The Great Chain of Being*, Lovejoy, 1936) we have grudgingly been forced by the import of the quantum revolution (which was self contradictory because it was literally simultaneously a revolt against continuity and the embrace of continuity [Bohm, 1976] in entanglement) to reevaluate our conceptions of the fundamental nature of "things" and even the framework of "space" in which they appear to be embedded. What we have in the manifest image called space and time are fundamentally ambiguous: looked at from the standpoint of recent physics, they are qualitatively different from what they had been supposed to be in prior theory.

I argue that time is fundamentally and qualitatively different also. When this is recognized it is time (pardon the expression) for a switch in our conception of time itself. Physical theory has exhibited a "political correctness" view saying that time can be eliminated from consideration, as it is "reversible" in dynamical lawfulness, and at best plays a "merely psychological" role in our lives. But if the fundamental limits of reality are (at least close to the Planck level) discontinuous and static, that approach is untenable. There is no physical theory of change that could pertain to stasis. We have to have a theory of change (rate dependence, dynamics) to get beyond the static, near Planck length bottom of the scale back through the quantum "level," through to the totality of the universe itself.

Time must be viewed from the perspective of the "prime mover" that *creates* the dynamics, and hence the observed lawfulness, of our universe. Theories of change of state are *ipso facto* theories of time, and time is thus indispensable to human understanding, and a presupposition of the universe that has *always* been evolving. The spatial realm, the realm of matter, is at rock bottom discontinuous,

static, and *not* intrinsically dynamic. It is time that supplies all the dynamism of our universe and ourselves.

Time in the Dimensionality of the Universe

Another factor needs to be considered when viewing time. Intuitively we tend to assign primacy to spatial dimensions. After we have included the number of spatial dimensions we are interested in we then "tack on" time as an afterthought, as the "last" dimension. We regard length as being one dimensional (since it requires only one point in a dimensional coordinate system to determine it), and intuitively we feel that this one-dimensionality represents the "first" dimension. Then width and depth represent the second and third dimension, and time, stuck on at the end, is regarded as "merely" the fourth dimension. This is completely backwards.

We have thought traditionally, as do those fish in the old tale of denizens of perfectly clear water who never manage to develop a theory of water as the medium in which their lives occur. Since they did not "see" it, or "sense" its presence, they never considered what it was or how it constrains their continued existence. If we are not to be like those fish we need to reconsider basic issues such as how we are enmeshed in time.

Consider the basic question of ontology: what exists? When we predicate existence to something, it really boils down to the attribution of a single thing — existence is defined by endurance through time. Existence equals endurance. And as such, existence is purely temporal, *without reference to continuity of "parts,"* and not primarily or otherwise spatial. When we ask what exists we want to know what *endures in the temporal dimension*. We do not first ask about its spatial dimensions — the attribution of length, width, or depth is inevitably a secondary consideration. And when we move beyond the traditional and obviously "purely physical" items to the problems of abstract exemplification we do not ask about spatial dimensionality *at all*. Does truth exist? Does beauty exist? No one ever asks about the width of truth, or the length or depth of beauty (indeed, there is no adequate scaling theory to do so [Weimer, in press] at present). All that we are interested in is whether or not the entity or process or attribution endures through time. Items in the purely conceptual or rate-independent realm, if they exist at all beyond neural activity, exist always and thus, removed from dynamical processes, are what we call "eternal." But that rate-independent realm, that eternity, depends in turn upon our existence as semiotic subjects who give it that meaning through what Pattee called "semantic (semiotic) closure." We have no evidence for the existence of any Platonic or Popperian semiotic realm that is independent of time or subjects. The requirement of physical embodiment for symbols prevents any "disembodied" realm of abstract exemplification.

If time is a dimension of the universe then it manifestly is not the "last" one. Time, not space, is *the first dimension*. Space does not exist independently of time:

it is an attribute of endurance in a universe of more than one dimension. Space endures through time. While space has been, epistemically, the first concern of conceptual analysis in understanding the physical realm, it has no actual ontological primacy. Considered from the perspective of ontology, if anything exists at all it must be time. Space in that sense is a secondary attribution, albeit one that has been our primary epistemic focus in the past. Physics of the twentieth century, first with relativity theory requiring the consideration of both space and time as co-existants, and then quantum mechanics showing the discreteness of so-called physical existence, has forced the realization that both factors must be considered together. And the problems posed by the nonexistence of continuity in rate-dependence, and the dimensionality of cognition, now force us to regard time as a (or perhaps the) primary dimension of the universe (if it can correctly be regarded as a dimension at all). Spatial properties have the characteristics we attribute to them only in virtue of their endurance through time.

Rate-Dependence, Rate-Independence, and Time

A presently insuperable problem for theory — physical theories for the time–space manifold, and functional theories for the semiotic and mental — is that they cannot conceivably be placed upon a continuum or directly related. They are in different phase spaces of existence. By acknowledging the tenseless realm of rate-independence we create an ultimate dualism. We are in exactly the same position as that described by physicist Max Born (1966) in "Symbol and Reality," when he pointed out that no matter how small and infinitesimal a probability is, there is always an infinite gap between it and zero or nothing at all. Nothing bridges that conceptual gap. So long as time is tacked on as an afterthought dimension this infinite gap must always exist between the temporal and the spatial. The only hope we have of understanding (which is always tenseless and timeless, and thus not a process at all in any normal sense of the word) time in relation to the world order is to conceive of time as the primary dimension. If we do so, the temporally compresent, the realm of understanding, can be conceived of as differentiating a dimension, one extreme of which is what we undergo as the specious present.

Order

We assume science is to explain the "order" of the universe (ourselves included). But at the smallest levels there seems to be neither (spatial) order nor disorder. And as von Neumann (1966) and Hayek (1952) emphasized long ago, we (as the activity of our nervous systems) seem to be "order" only in the sense of statistical patterns. The CNS is a temporal system (Hayek, 1952), not a spatial one. And as von Neumann emphasized, it is a *statistical* one: "The nervous system appears to be using a radically different system of notation from the ones we are familiar with

in ordinary arithmetics and mathematics…we have here a system of notations in which the meaning is conveyed by the *statistical* properties of the message" (von Neumann, 1958, p. 79). I wish to emphasize this: we are unlikely to learn much if we insist upon construing the statistical patterns of neural activity in terms of spatial dimensions. The patterning of the nervous system is not spatial: it is not anatomically localized, but occurs in dynamical patterns ranging over many anatomical structures. The patterning of the nervous system is temporal, and in an opportunistic sense, it utilizes whatever spatial devices (spatial "information" or "dimension") happen to be available. Our picture of the world order is built within the time dimension of our nervous systems, it is not laid out in spatial dimensional (2-D graphical) format. We are in a temporal time–space continuum, not a space–time spatial continuum. Our cognition — especially human meaning — is a temporal flow, not a series of somehow discrete spatial points. Recursive operations upon patterns of neural activity is what "we" are. Both human action and cognition are temporal patternings, not spatial movement. Time orders things differently from the way spatial position markers provide order.

The Notes Were Sour Because the Seams Were Split

Everything we can understand requires us to put it into a meaningful context. Human understanding is the creation of such contexts. Without a context to *disambiguate* the flux of events, there is no determinate meaning, and hence no understanding. We disambiguate by imposing (we say we are discovering) order on the indefinite welter of experience. That order is created by the patterns of our nervous activity (for cognition, primarily the "higher" brain functions), and it is therefore meaningful to our nervous systems. Meaning is relational patterns of nervous activity.

We divide and conquer the welter by looking for structure — the syntax of action — to break it up into pieces we can comprehend more easily. Because of the primacy of time, we package the output of the cloud of neural activity into linear strings. Our behavior and cognition is, as a result of evolution, eventually packaged into linear strings of things — into words in a language, or into functionally identifiable acts of behavior. In all cases, the key to explanation of the strings is the provision of a context into which the behavior can be fitted or to which it can be matched.

The revolution in linguistics in the last century provided a paradigm of understanding of behavior (language or action) in the theory of Post Languages, with its fundamental distinction of terminal (surface) and nonterminal (abstract or deep) entities, and the requirement of looking back over the derivational history of the string to disambiguate (to causally account for) the terminal string output. From this framework linguistics introduced the distinction between surface (terminal string) and deep (higher, tacit, abstract) structural ambiguity, and the explanatory

necessity of looking at derivational history to explain both the causal basis and the meaning of any string (behavior).

We explore some of the centrality of deep structural ambiguity below. This introductory excursus is to show that *all* output strings are *completely* dependent upon context to provide order and thus interpretation. Recall the section heading you puzzled over above. It is rendered meaningful and appropriate by contextualization with a single word: *bagpipes.*

We Are Denizens of the Semiotic Domain of Existence

We have attempted to build a picture of the world on the basis of syntax (order in space), and have supposed that semantics (to say nothing of pragmatics) are relatively minor additions to the spatial (i.e., syntactic) structuring we have painstakingly studied since the dawn of mathematics. Scholarly literature abounds with attempts to provide accounts of the nature of "information" in life and mind according to some "computational formula" analogous to the manner in which Claude Shannon mathematized the notion of "information" in communication channels. These formulas are all but useless because their authors do not realize that ratio scaled measures apply only to the physical universe, and that functional concepts (such as meaning, intentionality, purpose, function, etc.) are *not* in the physical universe but are instead in the rate-independent mental realm. Whether anything more than nominal and ordinal measures apply to functional or intentional concepts remains undetermined. The results of the formulas are thus meaningless gibberish, a "category mistake" combination of fundamentally incompatible concepts in some "equation" of integrals and sums over infinite domains and nondimensional "numbers" of indefinables. They attempt a shotgun marriage of incompatibles, with no realization that what is required is complementarity — accounts in both the physical and functional domains (as Pattee, 2012 long emphasized). Neither account can be "reduced" to the other, nor is it adequate alone. The phase spaces are concurrent, and do not actually touch or overlap each other at any "time" or "point" (as Hoffmeyer, 2003; Kauffman, 2019; and Weimer, 2021, 2022, in press have stated). Thus there is no physical approach with an equation of motion that can ever succeed in forcing them into the same phase space.

Meaning Is Not Just Information

We are talking about semantic or functional/intentional/purposeful meaning, which is not related to Shannon's structural information in any direct manner. Syntax, while it can *structure* semantic content, is not semantic meaning or content. Perhaps the easiest way to show this is with a deep structurally ambiguous example such as:

The shooting of the hunters was terrible.

Here we have one surface linear string — a specification of syntax — that is two separate meaningful sentences. The surface syntax — the Shannon bits of information — is identical, but they instantiate two quite different meanings. Syntax is not semantics. At best, syntax structures the *realization* of semantics. Understanding meaning requires one to "look back over the derivational history" of the action (or utterance, behavior, etc.) in a manner that is foreign to physical theory. That "looking" is to determine *which* syntactic structure was intended by the speaker. Were the hunters terrible shots, or is it that someone shooting them was terrible? Functionality is inevitably historical, following time's arrow of direction in its structure and meaning, whereas physicality is, in contrast, by definition atemporal or time reversible. All life requires one to have knowledge of the patterns of activity that its history instantiates before one can understand its present — present behavior, present intention, present meaning, etc. All such functional concepts are time dependent. Epistemically this means that we will never be able to write a single physical theory "equation of motion" for a living system, because the functional concepts in such an attempt would, if they were measurable in a meaningfully scaled fashion, be nonholonomic — incapable of integration into a "physical" system. And if they were not measurable in meaningful fashion they would not be integrable in any manner at all. As Polanyi (1969) was the first to emphasize, life is emergent from physicality and *harnesses* it, and with that emergence meaning emerges from the realm of meaningless syntactic Shannon bits.

The unfolding or "running off" of the structure of behavior — from the movement of an individual through to the market order of economic action through to the social domain of unintended consequences of action — is linear and syntactic. As such, it is at least in principle subject to mathematical formalization (because syntax *is* structure, and mathematics can [in principle] represent structure). But the meaning (semantics) of behavior — from the intention or function of the individual through to the meaning of a price in the economic order through to the tacit role of spontaneous social customs or practices — can only be determined by a concomitant functional analysis of the agency involved. And that determination requires temporal analysis, not static spatial analysis. The living universe is inherently temporal. Only the purely physical is spatial and atemporal.

Summary

Concepts of continuity, time, and order must be reinterpreted if we are to understand contemporary scientific inquiry into both the physical and the functional domains of living organisms. We need to orient away from both momentary static and continuous conceptions of spatial entities, and explore dynamic and temporal — inherently historical — accounts instead. Several points are salient:

1. There is no continuity at all in the observed physical universe. All seemingly continuous phenomena, including the mathematics of continuity, are actually discontinuous when examined at the level of the compositional details of their occurrence. No physical theory employs continuous fundamental existants (not even the wave equation in quantum accounts is actually continuous — the mathematics is bootstrapped discrete units integrated over time). No functional domain, even perception, is continuously variable (neural events are ultimately discrete, and again, are integrated over time).

2. Continuity is found only in the rate-independent realm of conceptual thought. Consciousness (of knowledge by description or meaning) is an integration over time, but its contents are in the specious present moment which does not have a time marker. Understanding a "concept" requires temporal tacit processing, but when a meaning "pops in" to consciousness it does so instantaneously insofar as our perception is concerned. Phenomenological cognition is rate-independent; physical and psychological theory are dynamical, or rate-dependent.

3. Time has traditionally been conceived as an "add on" dimension somehow appended to the spatial realm. In contemporary accounts it is "tacked on" at the end as a fourth dimension. Taken "down" to its shortest, the units of time are as discontinuous as those of physical phenomena. What our understanding needs is a theory of change, and only a theory of the temporal dimension seems to be able to address change since it does not appear at the smallest component levels of spatial–physical theory.

4. The psychological–epistemic problems of order — how cognition and knowledge can occur — must be reformulated as a result. Cognizing subjects are neural patterns — and patterns of patterns, indefinitely reiterated — and are thus primarily or ultimately temporal and statistical instead of spatial entities. We are temporal–statistical, not spatial–physical. We can only be interpreted unambiguously if we know the derivational history (providing the context) of our behavior.

References

Bergson, H. (1911). *Creative evolution* [A. Mitchell, Trans]. Holt, Rinehart and Winston.

Bohm, D. (1976). *Fragmentation and wholeness.* Van Leer.

Born, M. (1966). Symbol and reality. *Dialectica, 20*, 143–157.

Broad, C. D. (1949). The "nature" of a continuant. In H. Feigl and W. S. Sellars (Eds.), *Readings in philosophical analysis* (pp. 472–481). Appleton–Century–Crofts.

Campbell, D. T. (1974). Evolutionary epistemology. In P. A. Schilpp (Ed.), *The philosophy of Karl Popper* (pp. 413–463). Open Court.

Cassirer, E. (1957). *The philosophy of symbolic forms, Volume 3.* Yale University Press.

De Biase, F. (2009). Quantum–Holographic informational consciousness. *NeuroQuantology, 7*(4), 657–664.
Di Biase, F. (2019). Quantum entanglement of consciousness and space–time: A unified field of consciousness. *NeuroQuantology, 17*(3), 80–85.
Gibson, J. J. (1966). *The senses considered as perceptual systems.* Houghton Mifflin.
Gibson, J. J. (1979). *The ecological approach to visual perception.* Houghton Mifflin.
Gregory, R. H. (1966). *Eye and brain.* Princeton University Press.
Gregory, R. H. (1980). Perception as hypotheses. *Proceedings of the Royal Society of London, B 290,* 181–197.
Hayek, F. A. (1952). *The sensory order.* University of Chicago Press.
Hoffmeyer, J. (2003). Origin of species by natural translation. In S. Petrilli (Ed.), *Translation, translation* (pp. 329–346). Rodolpi.
Kauffman, S. A. (2019). *A world beyond physics.* Oxford University Press.
Longo, G., Montévil, M., and Kauffman, S. (2012). No entailing laws, but enablement in the evolution of the biosphere. In *Genetic and Evolutionary Computation Conference* (pp. 1379–1392). ACM.
Lovejoy, A. O. (1936). *The great chain of being.* Harper and Row.
Maxwell, G. (1968). Scientific realism and the causal theory of perception. In I. Lakatos and A. Musgrave (Eds.), *Problems in the philosophy of science* (pp. 148–177). North Holland.
Montévil, M., and Mossio, M. (2020). The identity of organisms in scientific practice: Integrating historical and relational conceptions. *Frontiers in Physiology, 11,* 1–13.
Pattee, H. H. (2012). *Laws, language and life*. Springer.
Pattee, H. H. (2013). Epistemic, evolutionary, and physical conditions for biological information. *Biosemiotics, 6*(1), 9–31
Polanyi, M. (1969). *Knowing and being* (M. Grene, Ed.). University of Chicago Press.
Pribram, K. H. (1971). *Languages of the brain*. Prentice–Hall.
Pribram, K. H. (1977). Some comments on the nature of the perceived universe. In R. Shaw and J. Bransford (Eds.), *Perceiving, acting, and knowing* (pp. 361–381). Lawrence Erlbaum.
Pribram, K. H. (1996). Quantum information processing in brain systems and the spiritual nature of mankind.. *Frontier Perspectives, 6*(1), 7–16.
Sellars, W. S. (1963). *Science, perception and reality.* Routledge and Kegan Paul.
Sherrington, C. S. (1963). *Man on his nature.* Cambridge University Press. (originally published 1906)
von Neumann, J. (1958). *The computer and the brain.* Yale University Press.
von Neumann, J. (1966). *Theory of self-reproducing automata.* University of Illinois Press.
Weiner, P. P. (Ed.), (1951). *Leibniz: Selections.* Charles Scribner's Sons.
Weimer, W. B. (1975). The psychology of inference and expectation: Some preliminary remarks. In G. Maxwell and R. M. Anderson (Eds.), *Induction, probability, and confirmation* (pp. 430–486). University of Minnesota Press.
Weimer, W. B. (2021). Problems of a causal theory of functional behavior:What the Hayek–Popper controversy illustrates for the 21st century part 1. *Cosmos + Taxis, 9*(11+12), 1–29.
Weimer, W. B. (2022). Problems of a causal theory of functional behavior: What the Hayek–Popper controversy illustrates for the 21st century part 2. *Cosmos + Taxis*, in press.
Weimer, W. B. (in press). *Epistemology of the human sciences.* Palgrave Macmillan.