Processual Explanation for the Historical Sciences

Haines Brown
Haines@histomat.net

16 October 2010

Abstract

The aim of this paper is to justify an ontology suitable for historical explanation, in preparation for its implementation. It transcends modern Western ontology by proposing a physical definition of process that takes action to be foundational. It addresses in particular the historical sciences that are concerned with emergent phenomena. It argues that conventional closed frameworks such as system, state of affairs, entities or levels, are only a hypothetical limiting case of emergent processes. Making action foundational implies a modal realism, but here possibility, potency and actuality are mutually defined and grounded in structure so that concrete particulars are never epiphenomenal. The interdependence of these modalities offers an operational definition of process: the localization of a probability distribution due to processes entering a relation that establishes novel structure. In lieu of the causal explanation appropriate to closed systems, explanation is here based on a determinant relation of processes, a "processual superposition." In terms of this relation, two kinds of emergence are defined: spontaneous and structural. Their relations in complex systems gives rise to the characteristic trajectories of such processes.

1 Introduction

The bourgeois revolution in Europe created a society that minimized constraints on the individual's exercise of private capacities. This had a profound ideological repercussion in modern Western thought.

Unbridled private interest was given legitimacy by representing it as an instance of the supposition that potency, meaning, or identity are properties that are intrinsic to things. The result was a reification of such conceptual dichotomies as part-whole, inside-outside, self-other, being-becoming, past-future, cause-effect and mind-matter. It also tended to reduce explanation to the operation of private mental powers, to epistemology, to predictions of causal effects governed by the abstract coherence of the world arising from a universal rationality (Kant) or universal laws (positivism).

This ideological position proved to be incompatible with some traditional notions in the West that had originated in Mediterranean antiquity, such as Heraclitus' belief that all things are processes and Aristotle's notion that process combines possibility and necessity. The modern Western

reduction of things to intrinsic properties ejected non-local possibilities from the natural world, to resurface as a quasi-divine capacity of the mind to transcend circumstance or as a useful fiction inferred from a placement along an imagined time-line.[1] It is the intent of this paper to rehabilitate a notion of process, but one that is naturalistic, has a physical basis and is operational.

In Europe the concept of process has been torn between a Continental view that represents possibility as an objective idea and an Anglo-American empiricism that makes it an artifact of mind. Given this split, Darwinism seemed to offer an escape because it handled emergent phenomena in naturalistic terms: random mutation (or more fashionably these days, noise) generates indeterminant real possibilities that are constrained by natural selection (Weiss, 1969; Bertellanffy, 1962). However, it is usually now understood that this objective randomness is implicitly dualist, and a materialist notion of process must represent randomness instead as only a high degree of physical improbability.[2] Hopes placed in the Darwinist new synthesis as a universal model for emergent processes in other sciences seems in retrospect misplaced (which perhaps can be said as well of general systems theory, non-equilibrium thermodynamics, chaos theory and complexity theory).

This paper will loosely draw upon, reconcile and develop a range of suggestions that have arisen in process philosophy and the philosophy of science in the last century or so. For example, central is the suggestion of Samuel Alexander that not only is process a universal primitive, but the localization of space and time is an effect of a relation of processes. This paper will also draw upon a hint offered in Henri Bergson's *Creative Evolution* that the engine of process is not an abstract idea, but thermodynamic dissipation. While process is universally expressed in temporal terms to accommodate the limitations of mind, it will be argued here that the constraint of the past and the emergence possibilities of the future do not take place in time. Indeed, what distinguishes an empiricist notion of process is its reification of time to avoid the contradiction implied by a state of affairs that is becoming.

A division persists between an idealism (as in A. N. Whitehead's notion of possibility as a relation of an entity to an objective ideal or Heidegger's *Time and Being*) and Anglo-American empiricism, for which a memory of the successive states of an identity along a time line and represented in thought as process. The inability of these paradigms to arrive at consensus seems due to their employing the contradictory ontology that arises from a reduction of things to their intrinsic properties.[3]

This paper is a prolegomenon to a study of a processual methodology in the social sciences.

2 A Foundation in Action

Outside the modern West people have generally felt that the essential nature of things depends on extrinsic properties, their relation with something else such as a divinity, political order or abstract

[1] While the notion of a time-line originated in the West a millennium before with the Venerable Bede, it was rooted in the Benedictine belief that material transcendence arises from entering a relation with the supernatural. The time-line was therefore not natural. The reification of McTaggart B-Time in naturalistic terms seems only to have emerged in the 18th to 19th centuries.

[2] There is insufficient room here to explore the argument that randomness means indeterminacy, which implies a non-natural ontological category for that which is absolute or non-contingent.

[3] The Continental approach seems to linger on in critical theory and structural realism (for example, Joas, 1996). For Anglo-American empiricism, see Rescher's (2000) introduction to the philosophy of process, which simply ignores the Continental tradition. For the importance of process in historiography see Ritter, 1986).

idea, and these relations were felt to constitute in large part their identity and meaning. However, in the modern West, the furniture of the world was reduced to sets of intrinsic properties. As a result, mind and world are "systems", are entities closed to one other, each characterized by the systemic properties that arise from the internal relations of their constituents.[4] The mind is characterized by ideas, rationality, will or a creative élan that is able to transcend the determinations of the natural and material world. Despite the contradiction, it is assumed that the mind and the material world somehow manage to interact and give rise to a property that is at once true to the world and yet does not thereby reduce to empirical data.[5]

In this paper mind and world are not separate entities, but are aspects of a broader process, a universal process or action. This is not action as it is conventionally understood as a causal relation of entities—an agent having the causal power to produce an observable effect in an object of action, but action as a power to actualize possibilities. What this means is that instead of inferring that the world is coherent and governed by necessity because action in it is efficacious, the world is understood to be what enables action, making it probable.[6] The outcome of action is not ruled by such abstractions as universal law or an indeterminant free will, but as will be seen is uniquely determined by the particulars of circumstance. In the former case, action determines; in the latter, it enables; in the former, freedom and determinism are contradictory; in the latter, action brings about what is improbable in relation to what exists.

If action is made foundational, it implies the world has a real possibility to be other than what it is, for this is a condition of action.[7] The world not only has a capacity to change, but it probably does change, for otherwise action ceases being foundational and stability rules. Change is the norm; stability the exception and so begs for explanation. In contrast, the empiricist sees a world in which the success of prediction implies that the world is a coherent causal structure governed by rules of necessity. For him, stable order is expected, and it is change that requires explanation. To put this contrast rather dramatically, if action is foundational, the condition of action is that the world is empirically incoherent and non-rational because action engages real possibilities that are neither.[8]

However, for the relationship of things to be in principle non-rational (as is the case with emergent levels), it is necessary to embrace what is called a deflationary notion of truth. This is because a substantive theory of truth refers to the relation of a closed statement and the closed entity to which it refers. The property of truthfulness confronts the conceptual contradiction of an indeterminant mind and deterministic world.

[4]It is conventional to speak of closed objects defined solely by their intrinsic properties—properties that are self-contained rather than extrinsic, as "entities" or systems. For the problems of imposing such closure on a world of qualities that are fluid and are continua, see Wright, 1992.

[5]The model for this was offered by Plotinus, who reconciled the absolute godhead and a contingent world by inserting between them a demi-urgos. A deflation of truth will be discussed later, but for examples of truth serving to reconcile the Cartesian mind-world contradiction in social action, see Münch, 1987, 6f., and Kilminster 1998.

[6]Possibility and potency, which unite as probability, is represented as being universal in the sense that all possibility and potency is inherited from the cosmos as a whole that arose from the Big Bang. For the point that the mind is best understood as situated in the world through action, see for example, Clark, 1998.

[7]It is sometimes argued by empiricists that what is unobservable is unreal because it has no causal effect on the retina. Despite this strange ocular bias, possibilities are in fact directly experienced through action, such as the knowledge of causality acquired by the haptic sense (White, 2006).

[8]For the primacy of action in terms of the traditional Western conceptual framework of reified categories, see for example the account and synthesis of Joas (1996). Joas' dialectical interactionism leaves creativity indeterminant and thus a non-naturalistic presupposition.

2.1 The uncertainty of truth value

The European Enlightenment held that because the Self is directly experienced and known, it offers a foundation for knowledge of the Other in terms of its relation to Self. This has caused problems.

One difficulty is that we know that the information acquired from observations of the world are mediated in various ways by our sensory or observational apparatus, by the limitations of mind, and by our social location and culture. While the resulting knowledge depends on the world, it is also emergent in that there is no empirical or analogical relation between a concept and the properties of the object to which it refers except by rules of translation. One can not justifiably speak of observational data as being 'raw' or presume that observational facts are foundational, basic or a priori.[9] Since meaning or truth is under-determined by the world, truth comes to depend on an array of of epistemological criteria to a avoid tumbling into a radical skepticism that reduces truth to the narcissistic self.

Furthermore, the truth-maker objection is that there can not in principle be any physical relation of the world and a statement about it because statements about the observable properties of the world are actual and exist in the present, but they refer to what is held in memory and no longer actual. Since the past does not actually exist in the present, there can be no causal or other physical relation upon which to ground the truth value of factual statements.

Pragmatism's inference that the success of an action implies that the knowledge informing it is probably or approximately true, limits truthfulness to closed (artificial) situations for which outcomes are predictable rather than emergent. Truthful knowledge is explanatory only for rare closed situations. In this paper action is not a test of the truth of knowledge, but is a unity of agent and world as superposed processes from which knowledge is an emergent effect rather than a cause of or a condition for the success of action.

The difficulties of assigning truth value as a property of statements has encouraged what is known as the deflationary theory of truth.[10] It holds that a truth claim conveys information only about the person making a statement of fact, not the relation of the statement and the world to which it refers; truth value is therefore epiphenomenal or a rhetorical device. Nevertheless, contrary to what one might infer, a deflationary theory of truth need not imply a radical skepticism, for it only points out that truth claims cannot be justified by a causal relation or correspondence between statements of fact and the observable properties of the world.

Although tempting, the present paper will not let all the air out of truth, or at least it will not expunge a determinant relation of statements of fact and the world to which they refer. While the underlying argument will become clearer when probabilistic coupling is discussed, the relation of a factual statement and the world is not to see them as a dialectic of entities, but instead as two processes that are superposed and have a coupling of their probabilities. That is, it is possible to explain the efficacy of intentional action without recourse to a correspondence theory or a retreat to mere post facto description as in pragmatism and instrumentalism.

[9] Some readers might quibble over this characterization of analog, but the word means that there is a resemblance at least in some respects. If it means a functional equivalence, it raises even more difficult issues. For an example of the limitations of observational data, see for example Raichle (2010), where it is shown that a visual image of the world is drawn almost entirely from memory rather than sensation.

[10] It might come as a surprise to non-philosophers that 21% of the philosophers in an informal survey said they prefer a deflationary theory of truth. A standard discussion, although rather philosophically abstract, is Kirkham (1995), especially chapter 10.

2.2 The limits of causal explanation

Scientific explanation is moving toward a singular causality, which is a description of the causal mechanism at work in particular cases, rather than an appeal to the force of non-contingent reified universal laws.[11] While singular causality does nicely bring into accord causal explanation in the natural and the historical sciences, there is nevertheless less understanding today of causality itself than ever before.

The failure to arrive at any consensus over causal explanation can be attributed to the underlying shared ontology—an assumption that a causal relation of types, tokens, events, states of affairs or probability distributions is a necessary or invariant relation, and explanation is a warrant for the attribution of necessity to those relations.

However, the fact is that action is generally not just an actualization of a necessary outcome (which is unlikely to happen in any case), but is also an intervention that produces novelty or an improbable result (which is why it takes work). So the relation of the successive states of affairs in a process can as well be represented both as bringing about novelty and as governed by necessity and, in fact processes somehow entail both. This will be discussed later, but the point here is that we need an explanation for why an outcome is both possible and necessary. Instead, they two become split, and the former is applied to so-called "open systems" and the latter to closed systems.[12]

An aim of this paper is to evade this morass entirely. It is generally agreed that a closed system represents a hypothetical or approximate limiting case on what is more universal, the so-called "open system." It therefore seems best to see this openness as being the general case, for which a closed system represents an exceptional or hypothetical constraint.

In mechanistic causal explanation (as for its related deductive logic), whatever happens can only be the effect of properties that are intrinsic to the causal relata. However, the outcome of all processes is in fact to some extent always equivocal and unexpected, which is why the physics student must quickly come to terms with standard deviation. In mechanistic terms, such unexpected outcomes are attributed to intrinsic properties that either were not included in the description of the initial state of the system (those of contingencies) or are beyond the powers of observation (hidden variables). The point is that in either case, the explanation of improbable outcomes is an epistemological artifact, how a situation was framed or what about it happens to fall within our powers of observation.

However, there is another possibility, which is that the property responsible for surprise might escape our observation because it is not entirely local. While the term "observables" is common jargon in the philosophy of science, it is notoriously difficult to pin down. A property may be unobservable not for epistemic reasons, but for the ontological reason that it is a relation (see Albert & Galchen, 2009). For example, a field has a specific property at specific points in space-

[11] Positivist causal law is a regular association of events of given type rather than tokens. Because this implies a reification of universals (Humphreys, 1989), there is talk of a causal system as having such intrinsic properties as causal power or dispositions to explain change. For a critique of this for its ultimately begging the question of change, see Norkus, 2005.

[12] "Open system" may be a contradiction in terms, for if a system is open, there is no systemic effect, which usually serves to define a system. Not discussed here is the so-called causal process. As vaguely defined by Wesley Salmon, it is a causal chain in which the relation of links remains unequivocally mechanistic. Because one end of the chain is improbable in relation to the other, this reduces to a description that hides the presence of a ghost in the chain rather than an explanation.

time, but because its space-time is not bounded, there is an unlimited range of possible values that are not solely determined by what is intrinsic, but are a function of framing or locale.

It seems that causality implies necessity, whether it be in terms of reified universal laws or singular causal mechanism, and so it is an approximation that is appropriate for relatively closed systems; it is a hypothetical limiting case of a more universal process that engages non-local properties. However, it remains to be shown here why all processes necessarily have such non-local properties.

2.3 Materialism and coherence

The basic issue is really that of materialism and its implication for these non-localized properties. Materialism is often mistaken for physicalism, but in fact it is simply the presumption of the ontological monism that underwrites effective action and universal intelligibility. Ontological monism means that the world is coherent in that all things stand in some kind of determinant relation. Experience shows that this relation is not an unequivocally necessary one, although more determinant than a mere description of accidental interactionism or the logical principle of anarchic non-contradiction.

For this reason it has often been suggested that a scientific ontology must transcend the problematic inside-outside contradiction of self-contained entities and should instead represent things as merely the local aspects or instances of a more universal physical coherence or process.[13] Unfortunately, the usual way to do this is to posit entities as standing in a hierarchy of levels, where the term hierarchy implies some kind of meaningful relation of otherwise closed entities. The implied ontology seems problematic in three ways.

First, the word level requires a demarcation that distinguishes one level from another in some way that is meaningful or "essential." If the level is defined in terms of intrinsic properties that are deemed essential, it becomes autarchic and ceases to be a meaningful level. If, on the other hand, non-local properties are introduced to give substance to hierarchy, then the level ceases being a meaningful unit of analysis.

Second, beside the issue of closure there is that of definition, for levels can refer to something as broad as the biosphere or as narrow as the pecking order of chickens. A hierarchy of levels calls for some parameter that is heuristic and distinguishes one level from another in some important way. Unfortunately, this parameter is usually epistemological. For example, it is commonly suggested that a useful relation of levels is in terms of their relative complexity (the number of nodes and their connections). As the term hierarchy implies, this parameter implicitly or explicitly acquires a value derived from the outside. For example, it is often assumed that greater complexity is for some reason better, for it increases constituents' degrees of freedom. For an anarchist this is clearly a good thing, but the point here is that a hierarchy of levels ends being epistemological or ideological.

Third, a representation of levels as entities raises the question of their relation. One possibility is that the levels, or the system as a whole and its constituent sub-systems taken as wholes, causally interact upward or downward, such as through recursive feedback loops. Because a structural

[13] At a very general and intuitive level, Lancelot Law Whyte (1949, p. v) argued for the relation of physics and biology, "Soon I realized that the discovery of a universal form of process was hindered by the intellectual separation of the processes of subjective experience from those of the objective world."

determinism tends to make nodes epiphenomenal and invites an indeterminant interactionism, mere description, explanation is pursued by taking one level as an independent variable: if the lower level determines the higher it is a reductionism; if the higher determines the lower, it is a holism.[14] Both reductionism and holism have received considerable critical attention, but they are not the concern here because the present paper aims to transcend the ontological contradiction of whole and part which gave rise to it in the first place.

For these reasons, it will also try to avoid the term level except in reference to just the local aspect of a broader process. For example, the biologist Waddington long ago suggested that genotype does not contain information transmitted to and expressed in phenotype, but instead defines a probability landscape that he described as canalization. Here genotype and phenotype are not levels in a hierarchy, for the genotype only constrains possibilities that lie beyond it (Jablonka, 2005, 63–65 et passim).

It is widely felt that process reconciles the particular and the universal, but the difficulty has been that the universal is generally understood to be the rational, ideal or creative aspect of a process, which contradicts mechanical determinism. Unfortunately, this implies an ontological dualism, and so the present paper places the universal on the physical basis of real possibilities. Since an actualization of possibility brings into being what is improbable, the appropriate measure of the relation of structures (or "levels") would be their relative improbability.

2.4 Ontological implications of action

It is usually assumed that action, human or otherwise, is a causal relation of closed entities, levels or systems—a subject or agent and an object of action. In the case of human agents, the actor is typically defined as an autonomous intentionality or free will, so action becomes the imposition of mind on matter (via synapses and muscles), even though matter and idea are ontologically contradictory.[15] The result is known as the mind-body problem to which a considerable literature has been devoted. In this paper, however, activity will not be a relation of such levels, but a unitary process in which what are called subject and object are merely aspects. Here the basic analytical unit is process rather than entity.

I will not here belabor the point often made in ethology and elsewhere that action is a precondition of thought. Acting in the world and knowledge of the world inferred from passive observation imply two quite different kinds of relation between self and other. A useful way to discuss this is in terms of what is meant by the ambivalent concept of "unobservables" in the philosophy of science.

The word observable is not a problem: it refers to a situation where the value of a property is determined by a frame of reference such as a causal relation, observation or manipulation. Perhaps unobservables can then be defined by negation as a property value that cannot be observed because it is not a potential object of knowledge (such as Ding-an-sich) or because the observed object lies beyond our power to manipulate (such as a gluon), or because it does not fall within any

[14] While there are undoubtedly situations in which a higher emergent level selects, weighs, or filters inputs from a lower or base level, it would be wrong to infer from the word "hierarchy" the primacy of this executive function at the expense of the base level that enables the emergent level (for examples of this error, see Clark (1996) and Weiss (1969). Weiss also confuses epistemic degrees-of-freedom with ontological probability.

[15] Because of its roots in slave society, the West has always had to confront a categorical contradiction between the absolute and the contingent. The usual resolution was to posit between them one or more levels that in some mysterious fashion unite the contradictory categories. Plotinus or Pseudo-Dionysius the Areopagite come to mind.

frame of reference.[16] The last definition, rather than the others, will be the one employed here. If process is unitary, there is no relation of entities or frame that serves to distinguish observable from unobservable or define what is or is not real. The real is what makes a difference independently of thought, and whether it happens to be empirical and stand in a causal relation with the visual senses is irrelevant.

Action engages not only a real possibility for an alternative state of affairs, but also the potency that drives change. Neither are directly observable. Nevertheless, they are directly experienced (White, 2006), although it seems our conceptual apparatus is based on visual images. Without the world offering real alternative possibilities, action in general can have no effect; without a potency, such possibilities never become actual (free energy or causal potency that happens to be present within an entity ultimately beg the question). Action would make no sense and, indeed, would be impossible in a static world.

I bring up the unit of the measurement of action, although it may not be immediately apparent why it is important in the historical sciences, where things are not subject to unequivocal prediction or precise measurement. When it comes to processes, there are no static empirical distinctions to underwrite measurement, and the unit of analysis is instead a measure of the power to bring about change, how much and how fast. For example, the Planck unit of action in quantum mechanics is erg/second, and "Planck's constant" is one of the five natural units in that field, sometimes referred to jokingly as "God's unit" because it is the unit for the creation of order. Explanation of a process addresses the work or effort needed to bring about an improbable state of affairs, not what follows from action such as a prediction of outcomes; it is what enables change, not what follows from it.

Since order arises from action, from work done, change is a priori and the condition of all existence (Layzer, 1990). Rather than action being attributed to an a priori entity, agent or subject that has causal potency, it is a process that actualizes possibilities to become entities. What are usually referred to as a "subject" and "object" or "cause" and "effect" of action are a posteriori. If process rather than entities are a priori, then entities are actualizations of shared possibilities, rather than autarchic subjects dominating objects as seen in Foucaultian social relations or mankind's exploitation of natural resources.

3 The Modalities of Possibility, Actuality and Potency

It is important to distinguish observation and action, even though both represent a causal relation with the world. Observation frames what in the world can produce an emergent effect on the observer's sensory apparatus; it engages only what can have causal effect. Action, on the other hand, reverses this relation and engages a world that is capable of change, its potency and possibilities (White, 1999).

Historically and in daily life possibility and potency are taken to be real in that they are assumed to be true of the world and to make a real difference. In walking to a corner were I to say, "I could turn right," it is generally assumed that this is a real option that falls within my powers. In

[16]For a clear discussion of the weakness of the positivist theoretical distinction of observable and unobservable, see Klee, 1997. For an example of unobservables being due to the absence of a frame of reference, see Giere, 2006. For information arising from a frame of reference, see Weinstein (2003). He argues that while a frame is relative, within that frame objectivity is possible. This paper will also distance itself from subjectivism, but through an even more extreme relativism.

philosophical terms this is a position known as modal realism, a belief that things really exist in ways other than just their actuality, their existence in the here and now. While in the modern West, the tendency was to reduce the world to just the intrinsic properties of actual structures capable of affecting the senses, this no longer seems quite so obvious, and the reality of other modalities is once again taken seriously.[17]

However, this paper differs from the modal realism of both pre-modern Western philosophy and the recently popular plurality of worlds interpretation, for it will argue that all three modalities are interdependent and are therefore anchored on structure.

3.1 Possibility as a modality (qualitative aspect of process)

While it is generally understood that a dissipation of an energy gradient or improbable order is the engine of all change, this does not specify the quality of that change (Needham, 1942). To represent quality in thought, it is necessary to engage the possibilities of things that go beyond just what has happened to have been actualized, for they are only a small subset of the possible. Without possibility, things could be no other than what they have always been, change would not occur, and intentional action, including that of experimental science, would be insane.[18]

Unfortunately, a metaphysical claim for the reality of possibility does not carry much weight, and it seems useful to explain in physical terms why possibility is a necessary condition for actual structures, and for this I turn to cosmology and quantum mechanics. The ultimate pre-condition of any tangible existence is what is called a perfect vacuum. This is virtual matter for which there is no distinction of possibility and actuality, and so there can be neither space nor time. However, with a break in its symmetry, perhaps by a Higgs mechanism, possibility and actuality become separate, and this gives rise to differentiated actual properties including that of mass, spatiality (to provide room for differentiated actualities), and potency (the relation of actuality and possibility).[19] Because this means there are multiple possible states that are accessible, there is a general movement of actuality from a less probable state to a more probable state, and this is the universal engine of change. On the other hand, actualities can enter mutual relations that are locally probable and so they resist the engine of change to slow the movement of improbable structure to its more probable state (more on this later).

But once there is actuality, wherein reside its real possibilities? What is their relation?[20] The empiricist approach holds that possibility is inferred from the memory of a sequence of actual states of affairs that are separate in time, and where each is a necessary condition for the next and therefore implies its possibility. This means that the only possibilities are those that happen to

[17] See for modal realism, Loux (1979). The present paper does not adopt David Lewis' currently popular plurality of possible worlds version of modal realism, for which see Stalnaker (1979) and the review of Lewis by Lycan (1988), who brings up points useful for the present paper.

[18] On the reality of possibilities, see for example, Bunge (1976). That possibilities cannot be adequately inferred from observation, see Wright (1990–1991). That possibility is a primitive rather than just a property of actual things inferred from their observation, see Shalkowski (1994). Technically, what will be employed here is a substantive aleatic modality *de re*.

[19] On symmetry-breaking, see Bernardi, 2008.

[20] Crawford Elder (2003) asks rhetorically, "Who would want to affirm the reality of properties the presence of which cannot, even in principle, be detected—not via any associated powers over non-sentient entities, and not via responses to that property by sentient creatures?" The position of this paper is that without the reality of unobservable possibilities and potency, action would be impossible. The active body trumps the reflective mind.

have been actualized, but clearly they are only a subset of all possibilities. If possibilities were only those actualized, there could in principle be no emergent processes in the first place; there could be no future.

It is argued below that possibilities are constrained by actuality, but this does not make possibilities entirely local, for these possibilities derive from the more universal parent process on which the local process imposes a constraint. That is, a process has access to all the possibilities of its parent process, although because of the constraint most of them are highly improbable. This will be conveyed by saying that possibilities are anchored to the constraining structure but arise from the probability distribution of the parent process. Given this, possibility will here be characterized as an "exogenous" modality to emphasize that the possibilities accessible to a process are due to the circumstances under which it arose and are not intrinsic to it. For example, a worm has access to all the possibilities of a physical object, but the constraint of its biological structure makes an actualization of most of them very unlikely.

While actual structure is observable, possibilities are not because they are not confined within a local frame. Some possibilities can be inferred from the observation of past outcomes, but they are not the full range of possibilities and are only those that happened to have become actual. One might infer unactualized possibilities from analogous situations, but such inferred possibilities are still only a subset, never all the exogenous possibilities that are accessible.

These points have been belabored because they lend support to an important implication: if a local constraining structure were to change, other exogenous possibilities necessarily become more probable.

3.2 Actuality as a modality (localization)

There has been a tendency of late to multiply modalities, but this paper will remain with the traditional ones of possibility, necessity and potency. However, it will substitute the word actuality for necessity, for necessity usually implies an unequivocal causal determinism. Since mechanistic causality in this paper will be an artifact of closure rather than universal, it seems preferable to refer to that modality as actuality. The term also better conveys the sense of spatio-temporal localization.

The first point here may be counter-intuitive and so it will have to be elaborated. It is that for possibilities to become locally actual, they must enter into a relation with another actual structure that frames and localizes them, which makes them observable.[21] This does not mean that things don't exist unless perceived, for their potency and probability distributions are real enough, and being unobservable should no longer cast doubt on their being real. While possibility means that things can be different and potency means that things will be different, actuality means that things are different, and difference is always a relation. Here an example will help.

A classic situation used in discussions of the probability of outcomes is the roll of a die. The empiricist points out that one can infer from an observation of a sufficient number of throws that each face has a statistically equal probability for showing up. However, this example is revealing. Because they do not affect the probability distribution of outcomes, the boundary conditions of gravity and the flat surface onto which the die is thrown are ignored, although the outcome depends on them. That is, if one were hypothetically to remove gravity and the flat surface and then inquire as to the chance of an outcome, the question becomes meaningless. Without them there is no actual

[21] For measurement of actual properties depending on a frame of reference, see Weinstein (2002).

outcome. The property of orientation possessed by structures lacks any specific value until, driven by the dissipation of gravity, it is constrained by the flat surface on which the die is thrown, which actualizes with equal probability one of six possible orientations.[22]

If I were to load the die to reduce its symmetry, the statistical outcome of throws would favor just one face. However, things are a bit more complicated than this, for how often the favored face shows up depends on the weight and location of the load. The greater its distance from the center, the more likely the favored face will appear and the more improbable the outcome. The less symmetrical and thus less probable the structure of the die, the narrower the probability distribution of possible outcomes. So, in general, the more improbable the structure of one process, ceteris paribus, the more improbable the probability distribution that emerges from their relations.

So far I have left an apparent contradiction unresolved. Probabilities result from the constraint of actual structure on exogenous possibilities, and yet structure is the constraint. This is a classic conundrum in Western science, such as the distinction of diachronic and synchronic analysis or that of structural and historicist explanation. Its resolution is that what is involved here is a becoming. A process simultaneously contains the past and the future. The point will be elaborated below.

Another problem is that in itself a structure lacks the specific actual property values to constrain unless it enters into a relation with another structure that frames it. So how can structure be a primitive? To resolve this, it is necessary to look more closely at "structure." It is usually defined as a set of nodes and their relations. If so, then each node localizes the others with which it stands in relation to acquire specific property values. The problem remains that these specific property values arising from internal relations have nothing to do with the structure of the whole that is supposed to constrain exogenous possibilities. The answer, again elaborated below, is that the relations into which nodes enter are not simply causal, but include their respective possibilities. It is the actualization of these possibilities that represent the emergent systemic properties of the whole. In short, the whole emerges from the nodes when they are seen as processes rather than as entities, and so the whole is implicate in the nodes and acquires the actual property values required to constrain exogenous possibilities.

3.3 Potency as a modality (quantitative aspect)

Potency is the quantity of action, of work that can be done, a capacity for change.[23] It is often treated as an intrinsic causal power or free energy such as that possessed by a firecracker not yet ignited, but adequate explanation requires that this potency be seen as a relation between the complex molecules of the powder and the more probable forms of energy and matter that result from its explosion. Ludwig Boltzmann early on realized that systems have a tendency to move from their actual state toward a more probable possible state. All matter is in motion in the sense that all actuality is an improbable state of affairs that tends to move to a more probable one.

Because Boltzmann's concern was thermodynamics, he expressed the difference between the actual and the more probable in terms of energy. However, the relation can as well refer to an improbable order, such as the improbable molecules of powder in the firecracker. Therefore, potency

[22] Assuming that all structures are in principle the actual modality of processes, I do not follow the conventional distinctions between the constraint of a boundary structure located at the surface of a system, the relation of system's constituents, or the relation of the structure of one process with that of another. Here they are all treated simply as relations of processes.

[23] For this and a number of other points raised in this paper as regards causality and localization, see Zangari (1992).

of action will here be termed a "probability gradient."[24]

The size of this probability gradient is in units of action. The greater the gradient the more is action efficacious and the more quickly will it seem to transpire. However, some structures have internal bonds that are highly probable and so appear to be relatively stable, and the probability for their change is more limited. Nevertheless, the gradient, however small it may be, always exists because all structure is improbable to some degree (even the proton has a half-life). In short, the impetus for change is not an intrinsic causal power, but a potency that is a relation of modalities, the modality of actuality and that of the possibilities constrained by actual structure. This potency is therefore "extrinsic," although not in the sense of a relation of an inside and outside, but as the relation of a modality that is local and one that is not.

Because possibilities are not local, but are far wider than what are actualized, the probability gradient is not local either, although one of its poles is anchored by a local constraining structure. Although unobservable, the probability gradient does have observable effects. Both the speed of change and the improbability of the outcome are a function of its magnitude. So, if one observes rapid change or the emergence of a highly improbable state of affairs, one can infer that the gradient driving it was large. On the other hand, stagnation may imply that the gradient was small.

As possibilities are actualized, the resulting new structure becomes the pole of a new, albeit necessarily smaller, probability gradient. So a new improbable order is driven by the reduction of the probability gradient of an old order. In thermodynamics this is called a thermodynamic engine. So, the universality of change is a unity and interdependence of two processes that are opposite with respect to their change in probability. One process is a reduction of a probability gradient called "dissipation", while its opposite, the appearance of an improbable structure and thus new probability gradient, known as "emergence."[25]

The example of crystal formation should help. When a crystal is grown in a supersaturated solution, the dissipation of the improbable concentration of the solution moves molecules into bonds that are more probable than if they were to remain in solution, and these bonds are constrained by molecular structure. While these molecular bonds are probable, their relation constitutes an order that is improbable because the molecular bonds actualize new possibilities. All structure is to a degree probable internally and improbable externally.

The Second Law of Thermodynamics states that the arithmetic sum of the processes that are opposite with respect to their change in probability, dissipation and emergence, must always be a net dissipation.[26] Each process cannot exist without the other. There can be no improbable order without there having been a dissipation of a probability gradient to drive it, and there can be no dissipation without the existence of an improbable structure as the pole of a probability gradient to constrain exogenous possibilities. This unity and interdependence of processes that are opposite with respect to their change in probability offers a fundamental analytical unit for the historical sciences, a processual contradiction, or more simply a contradiction so long as it is not confused

[24]It is common to posit an energy gradient as the basic driving force for emergent change, as in Scheider and Sagan (2005) and in Kaila and Annila (2008). Sometimes, however, the gradient is expressed in terms of order, as in Atkins (1984). Atkins speaks of a constructive chaos and its transformation into structure, but this seems to reify chaos and to marginalize empirical structure as epiphenomenal.

[25]Note that when speaking in physical terms, one instinctively thinks of these processes in relation to probability, while philosophers tend to translate the ontology into epistemology and see probability instead as predictability.

[26]It is important to emphasize that this is not because the law is universal, but because all potency arises from a dissipation of potency. The Second Law is merely a generalization of our observation of that fact.

with logical contradiction. A contradiction is a historical unit that is a measure of the probability of change.

4 Probability Distribution

We are now, hopefully, in a position to define process. A process is a relation of the three modalities in which each modality is defined by the others and is therefore anchored by actual structure.

- The relation of the modalities of actuality and its more probable possible states defines potency, the probability gradient that is the engine of change. Since each more probable possible state gives rise to its own gradient, the net result is usually described as a probability distribution.[27]

- The relation of the potency of an existing structure and the possibilities represented by its probability distribution gives rise to an emergent structure. Thus structure is simultaneously a presupposition and an outcome, a becoming rather than being.

- The relation of actuality and potency drives actuality to become other than what it already is, making it an aspect of a process. As will be discussed below, the rate at which this change occurs depends on the relative magnitude of the probability of the internal relations of the constituents of a structure and its probability as a whole in relation to its environment.

This can define how to represent "process" in thought so that it serves as an analytical tool suited to historical (emergent) phenomena. Nevertheless, the modalities are not separable in fact, and their analysis in this way only accommodates the limitations of mind.

Such a representation of change as an actualization of possibilities rather than driven by an intrinsic causal powers is by no means unusual.[28]

4.1 Probability distribution and time

The notion of process as a relation of modalities would appear to marginalize time. Indeed, it seems that an injection of time as an objective parameter is an artifact of empiricism and distinguishes it from the notion of process discussed here in which time is absent.

There are two conventional notions of time. The one that arises from the relation of memories is known as McTaggert B-Time (untensed time), where the event has no temporal part and is located along a mentally constructed time dimension. For example, Monday, Tuesday and Wednesday. However, since this view has no objective justification, an alternative is McTaggert A-Time (tensed time), where time is supposed to be a real extrinsic property that characterizes a temporal relation of events, such as yesterday, today and tomorrow (Mellor, 1998). The usual notion of process

[27]For a combination of a distribution of possibilities and a potency for change constituting a probability distribution, see Krips, 1989. Given the interdependence of modalities, the term probability distribution becomes a synonym for process.

[28]For explanation in terms of the pull of possibility rather than the push of necessity, see Martin (2007). I believe this accounts for the appeal of Darwinian theory: Blute (1997), Lenski (2005) and Quenette & Gerard (1993), and to some degree this paper can be seen as a critical development of Dyke (1987). For seeing chemical systems as driven by the actualization of real possibilities, see Bhushan and Rosenfeld (2000), particularly chapters 2, 4 and 7.

avoids the contradiction of the same identity having different states by displacing them along a temporal dimension like the beads of a necklace.

However, A-Time poses a difficulty, for only what is actual can enter a physical relation: what is past in time cannot causally influence the present any more than can the future.[29] So the challenge is to explain change without relying on time. That this can be done is suggested mathematically by the Markov process. Here a mathematical actual state of affairs determines the probability distribution of possible states of affairs. A Markov process "forgets" the past because only the present state is actual and relevant. Although it only a mathematical contrivance, a Markov process does suggest that it is possible to represent change in thought independently of time and instead as a relation of modalities.

Time can be dismissed as only a useful epistemological crutch. This might seem to leave a choice between actualism, presentism (in its philosophical rather than historiographic sense) and a denial of the present.[30] The position of this paper is that there is no past, future or present except as mental artifices to handle the relations of modalities that themselves have nothing to do with time.

Although passage of time can be understood as a relation of modalities, structures do seem to persist to varying degrees. There are contending theories to explain persistence, but the one adopted here is known as the structural interpretation of persistent identity. That is, the more probable are the relations of a system's constituents, the more probable and stable is its structure. Traces of the past that happen to survive into the present are not bits or aspects of a past that cannot exist in the present, but refer to the actual modality of processes that are stable because their internal bonds are relatively probable. The "past," in short, is simply actuality, and what seems to persist is an actuality with a relatively probable structure.

What of the future? The probability distribution of the present defines the probability of possible futures. While the future is "open" in the sense that a variety of outcomes are possible, these possibilities have varying degrees of probability, and so the future is not open in the sense of being indeterminant. The actual state of a system defines the probability of any future possible state and therefore the work or dissipation that will be required to construct it.

In short, what we represent in thought as being the past is the actual modality of a process, the future is its probability distribution, and, being a process, it has no present. Time is ontologically irrelevant.

5 The Dynamics of Processes

A representation of processes as a local constraint on exogenous possibilities that gives rise to a probability distribution, and the actualization of this probability distribution through a process entering a relation with another process (such as the relation of the nodes of a structure) has a variety of implications for their epistemic trajectories and study. Here I limit myself to the former and in particular the relation of processes and the issue of emergence. A methodology appropriate to an ontology based on processes represents a different project that lies beyond the scope of the

[29]Dorato (1998) argues that the objective becoming of A-Time has no scientific basis.

[30]This paper does not embrace actualism, for it apparently considers possibility a fiction. Presentism holds that only what is present is real and would deny non-local realities. For presentism and its critics, useful is Bigelow (1996). Bigelow argues that a notion of time as a fourth dimension on which are located ontologically independent past and future events is a product of 19th century European thinking.

present one.

5.1 Emergence

As popular as the word is, "emergence" is tricky. To start with, it is necessary to distinguish an ontological emergence from the epistemological point that the outcome of an emergent process is characterized by it being somewhat unpredictable.[31] In addition, there are fundamental disagreements over an understanding of ontological emergence. In the empiricist tradition, it refers to novel properties that are situated uncomfortably between the contradictory chairs of mechanistic reduction and vitalism. This is avoided if the term emergence, instead of referring to properties, is instead applied to whole systems or objects. This paper adopts this, admittedly unpopular, approach, for emergence here will be defined as improbability rather than unexpected properties.

This paper marginalizes systems, levels or entities as hypothetical limiting cases, and instead understands all things to be processes. Given this, the term emergence looses its utility, for all processes are emergent in that the past constrains possible futures and everything tends to be in motion.[32] It remains useful only as a way to draw attention to the improbable outcome of all processes.

A classic discussion of emergence was article by Stephen Pepper in 1926. Here was introduced, for the first time I believe, the word "supervene" to refer to the dependency of a novel outcome on an initial state or base level, but which does not reduce to its intrinsic properties.[33] While supervenience draws attention to the dependency of an emergent level on its base level, its exact nature is very difficult to unpack. This is why supervenience ultimately ends being descriptive rather than explanatory, as is illustrated below.

To escape reductionism to the intrinsic properties of a base level or initial state, there is a tendency to look there for some kind of unobservable property to account for non-reducible emergent properties. This has introduced some ambiguity into discussions because taking unobservables into account one remains a reductionist, although it is not a reduction to just observables. The issue is clarified if instead of observables, the issue is whether or not the unobservable factor or property is intrinsic.

However, even this is ambivalent. For example, the social sciences often seek to explain emergent observables by appealing to the presence at the base level of the unobservable property of functionality. However, this approach has been found wanting (Cummins, 1972; Giddens, 1977), for a property cannot be at once a cause and an effect. That is, functionality is extrinsic when the social situation is viewed in systemic terms and intrinsic when it is viewed historically.

The alternative here is to abandon the search for a hidden property that might account for emergence, but instead ask what it is about a situation that supports an improbable outcome. This approach is elaborated next as a processual superposition, but broadly it means that the constituents of the base level include their possibilities, and so emergence is simply an actualization of these

[31] For an example of the dead-end logical morass rather than physical explanation into which epistemic emergence leads, see Kim, 2000. I have the impression he avoids ontological emergence. He adopts the typical assumption that downward causation is somehow essential to emergentism, but such a causal relation of entities is here marginalized.

[32] The difficulty of establishing a relation of emergent levels is nicely illustrated by Emmeche (2000), who defines levels ontologically in terms of their relative complexity, but when it comes to their relation he retreats to epistemology.

[33] The term supervenience has acquired a variety of meanings, for which see Klee (1997, chapter 3). This may be why its introduction is sometimes attributed to writers later than Pepper.

possibilities. The advantage of this approach is that it brings in what determines the probability of an emergent state of affairs rather than posit a black box that stands in lieu of explanation.

5.2 Processual superposition

If all things in principle are processes, then the relation of what we think of as the constituents of a system, or the relation of emergent and base levels, or a dialectical interaction of entities, or the relation of whole and parts, all refer to relations of processes. Instead of a causal relation of entities, this relation will be represented as a "processual superposition."[34]

When two processes enter a relation, their probability distributions, probability gradients, and actual modality become entangled in a complex way:

- The intrinsic properties of each constrain the probability distribution of the other to make an otherwise unlikely outcome more probable.[35]
- A structure of a process can enter into a relation with another process and thereby frame its probability distribution to create an emergent structure that becomes the anchor of a new probability distribution.[36]
- The dissipation of the probability gradient of each process drives the emergence of the other, with the improbability of one determining the maximum improbability of the other.

A major difference between this processual superposition and a causal relation is that it is symmetric. As defined above each process participates in the superposition in the same way. In accord with this paper's rejection of time, neither is temporally privileged. In speaking of causality, we usually consider the first event as the cause and the subsequent event its effect. A temporal separation usually implies a hidden causal chain, but its links still imply temporal interfaces between past and present. Without such a temporal distinction, every causal agent is also an effect, and every effect is a cause.

Nevertheless, related processes can be distinguished by comparing the dissipation of their probability gradients. The one having the greatest dissipation produces more change in the other than the one having less. It can be represented in thought as the "cause", while the one with the lesser dissipation as the "effect." However, this distinction is only a convenience.

A probability superposition is a quite different kind of relation than causality. While each process experiences a dissipation of its probability gradient, it acquires greater improbability (potency) as it actualizes possibilities of the other. In other words, the work expended to construct relations based on diversity and thus different possibilities, offer the mechanism of mutual development so long as there is an adequate probability gradient to support it. This is quite different

[34] I borrow the term superposition from quantum mechanics, but use it only metaphorically. Useful in part for the position being developed here is the "dynamic emergence," discussed by Kronz & Tiehen (2002).

[35] In the literature there is discussion of the relative entropy of cause and effect to show that the latter acquires higher entropy. So it is important to note that the point here has to do rather with processes rather than the cause-effect dichotomy, and the frame or constraint imposed by one structure on the possibility space of the other necessarily gives rise instead to a less probable state of affairs.

[36] While this implies that entities arise from the relations of things, it needs to be emphasized that it does not reduce empiria to merely an artifact of relations, mere epiphenomena, for the relations are constrained by actual structure.

from Foucault's notion of social relations, which are a causal relation of self-contained entities and are therefore relations of domination.

An actual emergent structure is a combination of both probability distributions that enter the relation. For example, the retina of the eye has the possibility to generate an electro-chemical signal that travels through neurons to the brain. The process with which the retina enters a relation is that of photons, but the resulting electro-chemical signal has nothing to do with photons, although its probability distribution will be affected by their frequency and energy. More controversially, the signal transmitted to the brain arguably is not merely some information encoded as an electro-chemical structure, but its probability distribution as well, and so the signal conveys to the brain a sense of possibility as well as actuality.

5.3 Probability coupling

I turn now to what can be termed "probability coupling". So far the argument has been that processes are mutually enabling in that one creates the probability for the actualization of the other, although their potencies also shape the specific outcome. It might at first seem that attention has turned at this point to the ongoing relation of processes rather than their genesis, but this would cram the argument into the old ontological categories. That is, the conventional distinction between diachronic and synchronic analysis has little utility for a processual superposition: time has been deconstructed and diachronic refers to only the actual modality of a process. All processes are simultaneously synchronic and diachronic.

The basic point is simple enough: the relative improbability of one process creates the possibility for the emergent state of the other. However, the process may instead experience a hastening of its dissipation, in which case its constituents enter a less probable state. In the example of crystal formation above, a crystal is typically a very stable structure that lasts a long time, over 4 billion years in the case of zircons. But if a spontaneously emergent process (discussed below) enters a relation with a process having a sufficient probability gradient, such as the subduction of tectonic plates, the probability gradient makes molecular dissociation more probable than bonding, and the structure of the crystal has dissipated. However, in the case of the structurally emergent processes to be discussed, such a relation instead yields a less probable outcome.

While a relation of processes can result in either dissipation or emergence, when there is emergence, the more improbable the actual structure of one process, the more can it constrain the possibilities of the other to yield a more improbable outcome. For example, if you set out to fillet a fish, the sharper the knife, the less effort will the job take and the cleaner will probably be the result.

If the superposition of processes results in an emergent outcome, it means a less probable structure and thus a relatively greater probability gradient and potency for action. To stretch the little example above, a poorly cut fillet reduces the meat that ends up on the plate and thus the nutritional value of the meal. Of course, a clumsy chef can have the same effect even with a sharp knife, but ceteris paribus the more improbable the structure, the less a dissipation of the probability gradient (work) is needed to produce an improbable outcome.

Human action is efficacious because it improbably constrains the world. However, this is not because the action is informed by knowledge that is true to the world, but because knowledge is an improbable effect of the world's constraint on the mind. To put this in terms of linguistics, there is no relation of sign and signified that is necessary with regard to their observables. A false

conception is a conception that is not constrained by the world and so is less likely to have a desired effect.

With this in mind, two kinds of emergence will now be introduced. While all emergence is improbable in relation to its environment, there seem to be two flavors of emergence that are distinguished by whether relation of constituents is probable or improbable in terms of their intrinsic properties. These will be referred to respectively as spontaneous emergence and structural emergence.

5.4 Spontaneous emergence

In spontaneous emergence (conventionally termed "weak emergence"), the constituents of the system enter into relations that are more probable, given their intrinsic properties. The constituents mutually actualize their possibilities, and the resulting properties or behaviors are usually called "systemic properties" because they are attributable to the relations of constituents rather than their intrinsic properties.[37] These emergent properties are necessarily manifest in some structure, whether it be a physical boundary of the system, some other structure that enters processual superposition with it, or the constituents themselves.

It should be admitted that this is somewhat of a simplification, for the constituents can themselves emerge spontaneously as their own constituents enter a more probable relation. This gives a system a complex initial dynamic. However, as things settle down ("lock in" in general systems theory), the above generalization becomes more accurate.

Because the emergence of properties is driven by the dissipation of a probability gradient, there is an interdependence of emergence and dissipation: each process that is in a relation of superposition with another dissipates its own probability gradient to support emergence in the other. Often this relation is highly asymmetrical, so that one process is primarily dissipative and the other emergent. When this happens, we speak of the former as the "environment" of the process.

In terms of work, superposed processes are mutually contradictory, for the dissipation of one is what drives the emergence of the other. However, their relation ceases being contradictory if their mutual development is driven by a dissipation of some other process, particularly their environment. In other words, relations can be mutually empowering if in relation with a process that is primarily dissipative. When a set of contradictory processes have improbable outcomes because they have a relation with a primarily dissipative process, their environment, it is common to speak of the relation with an environment as the principal contradiction because it is the engine that drives the emergence of the other related processes.

The unity and interdependence of processes that are opposite with respect to the direction of their change in probability is a contradiction, and it is the natural unit for the analysis of historical processes.[38]

[37] For the spontaneous creation of novel observable properties, see Rubi (2008). For the use of dissipation in cosmology to explain the spontaneous origin of the novel structures of stars and galaxies, see Layzer (1990 and 1975). I believe this is why Harold Morowitz gives priority to metabolism over reproduction to explain the origins of life.

[38] Mario Bunge (1983, p. 30) speaks of the coexistence and intertwining of opposite relations, which he oddly characterizes as cooperation and competition. This implies an interdependent unity of emergence and dissipation, but it leaves the relations unhinged from empirical specificity, and his terminology seems anthropocentric. Bunge analyzes probabilistic explanation in these terms (pp. 26–31) and does recognize that even reductionist explanations engage

To avoid the logical contradiction of the same identity having different states in memory, spontaneous emergence acquires an apparent trajectory, a representation in mind of a succession of states placed on a mental time line. There are four such trajectories that should be mentioned.[39] While they are epistemological artifacts, their real basis is that at any moment in time a process has a probability for change that is constrained by inherited structure.

The first trajectory, already mentioned, is persistence. The structural theory of persistence suggests that when internal structure is probable it will seem to last because alternative possible states are less probable. Endurance is a function of the probability gradient, and the less improbable an actual state is in relation to a possible state, the smaller the probability gradient and the less quickly will change occur. While in epistemological terms persistence is often represented on the order of a person's memory, it actually can range from units of Planck time to cosmic time. So persistence has to do with the improbability of change rather than any temporal duration, although we nevertheless think of it as a trajectory that takes place in time.

The second is a deceleration. Change is driven by the dissipation of the probability gradient that drives a process to a less probable state. As a result of this dissipation of the engine of change, spontaneous emergence will appear to slow until a point is reached where there is an insufficient gradient to move to any other possible state. This deceleration ends in what is often called stagnation or crystallization. Again it is wise to put this in non-temporal terms, which can be done by describing this decreasing capacity for change as an increasing depth of the contradiction. The depth of a system's contradiction marks its relative age.

Third is what is known as "maturation." At first a system is relatively open to alternative possibilities because actualized structure is incipient and therefore quantitatively less improbable, but with its development a probabilistically favored actualization will generally prevail over others. In general systems theory, this is spoken of as an immature system "locking in" so that it comes to develop quantitatively rather than qualitatively; it has "matured" (Carneiro, 2000). This is also an indicator of the age of a system, but here age not the decrease of the probability gradient, but the reduced width of the probability distribution.

Finally is phase transition. Probability distributions usually have several peaks representing more probable states separated by valleys of relatively improbable states (called "probability wells"). So, to move from one probable state to another requires passing through a relatively improbable state, and so to get there requires doing work (I disregard the opening of new paths by tunneling and catalysts)—a sufficient dissipation of a probability gradient. While an expenditure of work admittedly does not seem very spontaneous, it nevertheless satisfies the definition of spontaneous emergence, and a new set of relations of constituents appears based on their emergent properties.[40]

5.5 Structural emergence

Structural emergence, in contrast with spontaneous emergence, refers to a situation in which an emergent structure is improbable in relation to the intrinsic properties of its constituents.

---

unobservable relations (pp. 35–41).

[39]The following points fall under what is known as general systems theory. For an introduction, see Blauberg, 1977. Broadly speaking they are not particularly controversial, and the aim here is one of accommodation.

[40]I should note that the term "stages" is used for both maturation and for phase transitions, which makes it ambivalent.

Such an unlikely situation is the consequence of a special kind of system boundary, often called an interface. While different sciences have their own name for it such as wall, barrier, gate, mediation, surfactant, membrane, or diode, the term interface seems usefully generic. The interface is an asymmetrical physical structure that defines two probability gradients. One stands in relation to the system's environment and the other, which depends on the first, defines the probability gradient for the system's constituents. This makes a possible relation of constituents more probable than one based solely on their intrinsic properties.[41]

The result is a state of affairs that is not only improbable in relation to its environment, but is improbable internally as well, for its constituents have entered a relation that is improbable in terms of their intrinsic properties. This improbable order must be supported by a continual dissipation of the system's principle probability gradient to override the pull of the more probable relations implied by the constituents' properties. For this reason, structural emergence is often referred to as a "dissipative system." It is also called a "non-equilibrium" system because its emergent structure is improbable in relation to its constituents' properties. Should the principle contradiction deepen, the improbable structure collapses and constituents enter relations defined by their intrinsic properties (for example, Sheldrake (1981), pp. 59–64).

It is important to emphasize that the improbable relations entered upon by constituents is not independent of their intrinsic properties, for the probability gradient established by the interface is superposed on that implied by constituents' intrinsic properties, so that the aggregate probability distribution depends on both the properties of the interface and those of the system's constituents. This point and the one above might seem minor technicalities, but they are of considerable importance for systems in which the intrinsic properties of constituents are emergent.

5.6 Trajectories of structurally emergent processes

The most obvious difference in the trajectories of spontaneously and structurally emergent processes is that the former typically persist and the latter, ceteris paribus, tend to collapse.

Both spontaneous and structural emergence occur in all domains, the cosmos, the biosphere and the noosphere. An example of structural emergence in inorganic nature is the dissipative system of a tropical cyclone. Its far-from-equilibrium state is maintained by the exothermic condensation of rising moist air from the warm ocean surface. Because its principal contradiction engages virtually inexhaustible solar energy, once the storm begins, there is nothing to stop it (the storm of Jupiter being virtually perpetual) except for the contingency of the Coriolis effect that eventually brings the storm over waters less warmed by solar radiation. While we understand the mechanism that drives a tropical cyclone, its path and intensity are not very constrained by the intrinsic properties of its constituents. Generally, the greater the principal probability gradient of a structurally emergent process, the less predictable will be its trajectory in relation to the actual properties of constituents.

A trajectory must obviously be sustained primarily by the principal contradiction, but in the case of structural emergence, important is a possible significant spontaneous emergence of its constituents. If this happens, the probability of their entering relations based on their intrinsic properties will increase, and this means an ever greater dissipation of the principal probability

[41] Although an interface dissipates heat, it does not do work and instead only constrains the dissipation of the principle probability gradient. This may seem a minor point, but it is actually important for the analysis of particular systems.

gradient is needed to override the tendency. As a result, a structurally emergent system that has spontaneously emergent constituents must constantly increase its principle probability gradient just to maintain its non-equilibrium structure. There is a range of strategies to accomplish this, such as alterations in the interface, but these matters concern specific kinds of systems rather than the how to represent the world in terms of processes and are not of concern here.

A structurally emergent system having spontaneously emergent constituents opens a quite different kind of trajectory in which the structure of the system is periodically transformed. This structural change is usually termed a revolution, which is made possible and necessary by the evolutionary spontaneous emergence of constituents and the deepening of the principle contradiction (for an example of such a trajectory that alternates between evolution and revolution see Bartel et al., 1976). Here the emergent development of constituents increases the probability of relations based on their emergent properties, but the interface overrides this as long as the principle contradiction has not deepened. In the absence of temporary strategies to delay a deepening of the principle contradiction, the system finds it difficult to maintain its far from equilibrium structure. This can be represented as systemic needs, which is to say conditions necessary for the perpetuation of the far-from-equilibrium system. While they can in principle be met by drawing upon the emergent developed possibilities of constituents, it is countered by the interface. The interdependent combination of these new possibilities and a declining ability to meet system needs is the basis of structural transformation that accommodates the developed capacities of constituents.

Although this scenario depends on an array of specific conditions, it is worth mentioning because it is not unusual. An example is the non-adaptive morphological transformation of an organism such as a mosquito that passes from one stage to another, from egg to larva, pupa and finally to imago. At each stage, internal development transcends the contradictions of old structure by actualizing newly emergent possibilities.

6 Conclusion

This paper has sought to avoid an epistemological primacy and thus particularistic world views such as Eurocentrism. This is not to say that ontological primacy implies objectivism, but if it is understood in terms such as explored in this paper, emergence arising from a unity of diversity lends itself to a more universal perspective. This does not deny the European contribution, but draws upon its possibilities for its transcendence. The past does not define the present, but only constrains it, and effective action looks to possibilities offered by greatest empirical diversity made accessible within a given structure of development.

While this paper specifically addresses the historical sciences of emergent phenomena, it should be evident that it applies in principle to all sciences. The reason is that if all things are emergent processes in principle, a closed and predictable system is only a limiting case. In these terms, a non-historical science is simply a historical science that is relatively closed.

While possibility, potency and actuality are the modalities of a process, we can only represent them in thought one-sidedly as separate aspects so that they become operational in communications and the acquisition of new knowledge. The validation of such knowledge is found in action, not in the sense of the successful production of desirable outcomes, as in pragmatism, but in being able to ascertain the relative probabilities for possible action and how much work it will take to actualize them. The test is not the result of action, but the probability of its being effective. One never knows

exactly how things will turn out, but one can to some extent explain them by what enables them.

An implication is that conceptual categories suited to explanation are not entities that happen to share the same "essential" (persistent) empirical properties, but a set of processes that share a relation to possibilities and a probability gradient that makes their emergence possible and probable. For example, social class would be understood as people sharing a relation of production rather than the empiricist notion of class as people who happen to manifest the same persistent properties.

Finally, an adequate conception of process should help with the problem of empirical selectivity, such as in factor analysis. It offers an alternative to the privileging of persistent properties in the construction of the general categories used to explain historical development despite history being anything but static. The approach outlined here avoids a subjective weighing of the relative importance of factors or gratuitous contingencies for predicting outcomes. In a process all empirical qualities constrain possibilities, and the object is not to privilege one over another in order to predict or to generalize, but to assess the resulting probability distribution.

References

[1] Albert, David Z. & Rivka Galchen. (2009). Was Einstein Wrong?: A Quantum Threat to Special Relativity. Scientific American, 300, no. 6, 32–39.

[2] Atkins, Peter W. (1984). The Second Law. (New York: Scientific American Library).

[3] Bartel, Horst and Heinz Helmert and Wolfgang Küttler and Gustav Seeber (Eds.), Evolution und Revolution in der Weltgeschichte: Ernst Engelberg zum 65. Geburgstag. 2 volumes. (Berlin: Adademie-Verlag, 1976).

[4] Bernardi, G. and M. Carena and T. Junk (2008). Higgs Bosons: Theory and Searches. (URL: `http://pdg.lbl.gov/2008/reviews/higgs_s055.pdf`).

[5] Bertellanffy, Ludvig von. (1969). Chance or Law. (In Arthur Koestler and John R. Smythies (Eds.), Beyond Reductionism: New Perspectives in the Life Sciences. The Alpbach Symposium, pp. 56–84). (London: Hutchinson).

[6] Bhushan, Nalini and Stuart Rosenfeld (Eds). (2000). Of Minds and Molecules: New Philosophical Prospects on Chemistry. (Oxford: Oxford University Press).

[7] Bigelow, John. (1996). Presentism and Properties. Noûs, 30, 35–52.

[8] Blauberg, I.V. and V. N. Sadovsky and E. G. Yudin (Eds.), Systems Theory: Philosophical and Methodological Problems. (Moscow: Progress Publishers, 1977).

[9] Blute, Marion. (1997). History versus Science: The Evolutionary Solution. Canadian Journal of Sociology, 22, 345–364.

[10] Bunge, Mario. (1976). Possibility and Probability. (In William L. Harper and C. Hooker (Eds.), Foundations of Probability Theory, Statistical Inference, and Statistical Theories of Science, III (pp. 17–33)). (Dordrecht: Reidel).

[11] —. (1983). Treatise on Basic Philosophy, 6. (Dordrecht: D. Reidel).

[12] Carniero, Robert L. (2000). The Transition from Quantity to Quality: A Neglected Causal Mechanism in Accounting for Social Evolution. Proceedings of the National Academy of Sciences of the United States of America, 97, 12926–12931.

[13] Clark, Andy. (1996). Being There: Putting Brain, Body, and World Together Again. (Cambridge MA: MIT Press).

[14] —. (1998). Where Brain, Body, and World Collide. Daedalus, 127, 257–280.

[15] Cummins, Robert. (1972). Functional Analysis. The Journal of Philosophy, 2, 741–765.

[16] Dorato, Mauro. (2000). Becoming and the Arrow of Causation. Philosophy of Science. 67, S523–S534.

[17] Dyke, Charles. (1988). The Evolutionary Dynamics of Complex Systems: A Study in Biosocial Complexity. (Oxford: Oxford University Press).

[18] Elder, Crawford L. (2003). Alexander's Dictum and the Reality of Familiar Objects. Topoi, 22, 163–171.

[19] Emmeche, Claus and Simo Kppe and Frederik Stjernfelt. (2000). Levels, Emergence, and Three Versions of Downward Causation. (In Peter Bgh Andersen, et al., (Eds.), Downward Causation: Minds, Bodies and Matter (pp.13–34). (Aarhuus DK: Aarhuus University Press).

[20] Giddens, Anthony. (1977). Functionalism: Aprs la lutte. (In Anthony Giddens, Studies in Social and Political Theory (pp. 96–134)). (New York: Basic Books).

[21] Giere, Ronald N. (2006). Scientific Perspectivism. (Chicago IL: University of Chicago Press).

[22] Heidegger, Martin. (1962). Being and Time.(New York: Harper & Row).

[23] Humphreys, Paul. (1989). The Chances of Explanation: Causal Explanation in the Social, Medical and Physical Sciences. (Princeton NJ, Princeton University Press).

[24] Jablonka, Eva and Marion J. Lamb. (2005). Evolution in Four Dimensions: Genetic, Epigenetic, Behavioral, and Symbolic Variation in the history of Life. Cambridge MA: MIT Press.

[25] Joas, Hans. (1996). The Creativity of Action. (Chicago: University of Chicago Press).

[26] Kaila, Ville R. I. and Arto Annila. (2008). Natural Selection for Least Action. Proceedings of the Royal Society A, 46, 3055–3070.

[27] Kilminster, Richard. (1998). The Sociological Revolution: From the Enlightenment to the Global Age. (London: Routledge).

[28] Kim, Jaegwon. Making Sense of Downward Causation. (In Peter Bgh Andersen, et al. (Eds.), Downward Causation, pp. 305–321. (Aarhuus DK: Aarhuus University Press).

[29] Kirkham, Richard L. (1995). Theories of Truth: A Critical Introduction. (Cambridge MA: MIT Press).

[30] Klee, Robert L. (1997). Introduction to the Philosophy of Science: Cutting Nature at Its Seams. (New York: Oxford University Press).

[31] Krips, Henry. 1989. Propensity interpretation for quantum probabilities. The Philosophical Quarterly, 39, 308–333.

[32] Kronz, Frederick M. and Justin T. Tiehen. (2002). Emergence and Quantum Mechanics. Philosophy of Science, 69, 324–347.

[33] Layzer, David. (1975). The Arrow of Time. Scientific American, 25, no. 12, 56–69.

[34] —. 1990. Cosmogenesis: The Growth of Order in the Universe. (New York: Oxford University Press).

[35] Lenski, Gerhard. (2005). Ecological-Evolutionary Theory: Principles and Applications. (Boulder CO: Paradigm).

[36] Loux, Michael J. (1979). Introduction: Modality and Metaphysics. (In Michael J. Loux (Ed.), The Possible and the Actual: Readings in the Metaphysics of Modality, pp. 15–64. (Ithaca NY: Cornell University Press).

[37] Lycan, William G. (1988). Review of On the Plurality of Worlds by David Lewis. The Journal of Philosophy, 85, 42–47.

[38] Martin, Peter. (2007). Probability as a physical Motive. Letter to the Editor. Entropy, no. 9, 42–57.

[39] Mellor, David Hugh. (1998). Real Time II. (London: Routledge).

[40] Münch, Richard. (1987). Theory of Action: Towards a New Synthesis Going beyond Parsons (London: Routledge & Kegan Paul).

[41] Needham, Joseph. (1942). Evolution and Thermodynamics: A Paradox with Social Significance. Science and Society, 6, 352-375.

[42] Norkus, Zenonas. (2005). Mechanisms as Miracle Makers? The Rise and Inconsistencies of the 'Mechanismic Approach' in Social Science and History. History and Theory, 44, 348–372.

[43] Pepper, Stephen C. (1926)1926. Emergence. The Journal of Philosophy, 23, 241–245.

[44] Quenette, P.-Y. & J. F. Gerard. (1993). Why Biologists Do Not Think like Newtonian Physicists. Oikos, 68, 361–363.

[45] Rubi, J. Miguel. (2008). The Long Arm of the Second Law. Scientific American, 299, no.5, 62–67.

[46] Raichle, Marcus E. (2010). The Brain's Dark Energy. Scientific American, 302, 44–49.

[47] Rescher, Nicholas. (2000). Process Philosophy: A Survey of Basic Issues. (Pittsburgh PA: University of Pittsburgh Press).

[48] Ritter, Harry. (1986). Process, Dictionary of Concepts in History (pp. 330–339). (New York: Greenwood Press).

[49] Schneider, Eric D. and Dorion Sagan. (2005). Into the Cool: Energy Flow, Thermodynamics and Life. (Chicago IL: University of Chicago Press).

[50] Shalkowski, Scott A. (1994). The Ontological Ground of the Alethic Modality. The Philosophical Review, 103, 669–688.

[51] Sheldrake, Rupert. (1981). A New Science of Life: The Hypothesis for Formative Causation. (Los Angeles CA: Jeremy P. Tarcher).

[52] Stalnacker, Robert C. (1979). Possible Worlds. (In Michael J. Loux (Ed.), The Possible and the Actual: Readings in the Metaphysics of Modality, pp. 225–234). (Ithaca NY: Cornell University Press).

[53] Weinstein, Steven. (2003). Objectivity, Information, and Maxwell's Demon. Philosophy of Science, 70, 1245–1255.

[54] Weiss, Paul A. (1969). The Living System: Determinism Stratified. (In Arthur Koestler and John R. Smythies (Eds.), Beyond Reductionism: New Perspectives in the Life Sciences. The Alpbach Symposium, pp. 3–55). (London: Hutchinson).

[55] White, Peter A. (1999). Toward a Causal Realist Account of Causal Understanding. American Journal of Psychology, 112, 605–642.

[56] White, Peter A. (2006). The Role of Activity in Visual Impression of Causality. Acta Psychologica, 123, 166—185.

[57] Whyte, Lancelot Law. (1949). The Unitary Principle in Physics and Biology. (New York: Henry Holt).

[58] Wright, Andrew. (1990–1991). Dispositions, Anti-Realism and Empiricism. Proceedings of the Aristotelian Society, N.S. 91, 39–59.

[59] Wright, Edmond. (1992). The Entity Fallacy in Epistemology. Philosophy, 67, 33–50.

[60] Zangari, Mark Zangari. (1992). Adding potential to a Physical Theory of Causation. Proceedings of the Biennial Meeting of the Philosophy of Science Association, 1: Contributed Papers, 261–273.