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Dynamics Is Not Enough: An Interactivist Perspective

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Abstract
An underlying process metaphysics is, arguably, necessary, but it is not sufficient for understanding the world, and, in particular, for understanding the mind and its development. It is necessary for both logical and empirical reasons, but we also need to account, *within* such a dynamic framework, for emergent normativity, adaptability, and cognition, among other phenomena, in order to model development. I will sketch these arguments, and then outline a model of development within that framework, with a brief introduction to how these processes are realized in the brain.

There are four sequential claims that I will be addressing. The first is that *process metaphysics* yields the possibility of *metaphysical emergence*. The second is that certain kinds of *thermodynamic* processes yield *normative emergence*, including normative *function* and *representation*. These models, in turn, force an *evolutionary epistemology*, which yields models of *learning* and *development*. Finally, these models can be realized in processes in the *brain*.

The two initial dependencies also hold in the reverse order: models of the emergence of *normative* phenomena require an account of *metaphysical* emergence more generally, and, conversely, metaphysical emergence, so I argue, is only explicable within a process metaphysics. So, if this is correct, the whole framework to be presented is *necessarily* grounded in process metaphysics.

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Metaphysical Emergence

Why Metaphysics?

Why address metaphysics at all? Is metaphysics not just a part of armchair philosophy, irrelevant to real science? This naïve empiricist-inductivist prejudice is not as strong in psychology as it was a few decades ago and is almost entirely absent in contemporary philosophy of science, but the prejudice is still an issue that needs to be addressed (Bickhard, 1992c, 2001).

Most basically, metaphysics and metaphysical assumptions – both explicit as well as unexamined implicit or background assumptions – frame and constrain (and sometimes force) theory and methodology. Science cannot be done without metaphysical grounding, whether examined or ideologically unexamined. Metaphysics is not scientifically irrelevant.

These constraints and enablings reach all the way down to specifics of experimental design. For example, control conditions will not be designed for possibilities that are *not* possibilities within a background presupposed metaphysics. Conversely, the conditions that *are* addressed with controls are the most salient from *within* the accepted metaphysics. A false metaphysics can, thus, constrain and enable in ways that can be seriously deleterious (Allen & Bickhard, 2013).

The case of associationistic behaviorism is well known: associations, we now hold, are neither metaphysically nor theoretically foundational – they are at best descriptive, and alternatives such as various kinds of constructivism are ignored or not even conceived of. I would argue that dominant frameworks of today, e.g., information-processing models, are similarly at root metaphysically impossible and are deleterious in their effects (Bickhard, 2009, 2014).

Metaphysics, then, is importantly relevant. The ideology that held otherwise was a self-protecting epistemology and metaphysics of naïve empiricism that dominated psychology throughout much of the twentieth century (Bickhard, 1992c).

Why Process Metaphysics?

Western thought has been dominated by some version of a particle or substance metaphysics. Empedoclean earth, air, fire, and water exemplify a substance metaphysics, while Democritean atoms were an early particle model. Substance models dominated for much of Western history, while today we are suffused with particle and structure[1] assumptions. Process metaphysics can be found sporadically and partially, beginning at least with Heraclitus, but has never displaced dominant substance or atomistic frameworks.

Nevertheless, process metaphysics seems to be forced by both logical and by physical considerations. Logically, a pure particle metaphysics is seriously problematic, if not incoherent. Point particles in themselves could not interact. They would never hit each other. And they have no way of attracting or repelling each other. A universe of nothing but point particles would be a universe in which nothing ever happened.

[1] I.e., configurations of particles.

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Contemporary popular physics "solves" this problem by postulating *fields* that enable interactions among particles, including attractions, repulsions, decays, and creations. This is at best an approximation, but it already admits fields as physically and metaphysically fundamental – and fields are processes.

More carefully, however, according to contemporary physics, *there are no particles* (Weinberg, 1977, 1995; Cao, 1999; Huggett, 2000; Halvorson & Clifton, 2002; Zee, 2003; Fraser, 2008; Hobson, 2013). There are quantum fields and quantized excitations in those quantum fields. Quantization is all that is left of the intuition of a particle. But guitar string vibrations are also quantized (and for mathematically parallel reasons), and there are no guitar sound particles.

Thus, everything is organizations of and interactions of quantum fields (including space-time), and quantum fields are processes. We have a pure process physics, and, therefore, a deep problem for any particle metaphysics.

Dynamics?

The title of this paper is "Dynamics is not enough." What does that mean? Dynamics is a conceptual and mathematical framework for modeling processes – in a broad sense. It is not specific to a nonparticle metaphysics. One classical dynamic model, for example, is that of two or three balls in a box. This is clearly an example of dynamics, and process, but is not necessarily framed within a process *metaphysics*: e.g., the balls could be construed as being constituted out of fundamental particles, instead of quantum field processes.

Dynamics is, thus, necessary, but dynamics does not necessarily (in itself) support important further consequences of process metaphysics that are addressed below – such as emergence and, in particular, normative emergence.

Metaphysical Stability and Change

A basic distinction between substance and particle metaphysics, on one hand, and process metaphysics, on the other, concerns stability: what is the fundamental, default, grounding condition – stability or change? Western thought has been dominated by the assumption that there cannot be change without there being some underlying unchanging substrate – e.g., substances or particles. Change – process – cannot itself be fundamental and, if it is posited at all, requires special explanation (Gill, 1989; Campbell, 1992, 2015).

Process metaphysics makes the opposite basic assumption – change is the metaphysical default – and, thus, it is stability that requires special explanation. This difference is of special importance for later discussion.

Particulars and Relationalism

A related issue has to do with *particulars*. Particulars are supposed to exist independently of anything else: there are no relations that are *intrinsic* to what a particular is. A (postulated) single basic particle would be one kind of example. Particulars can be in relationships with other particulars and can engage in change relative to others (a kind of process, as with billiard balls or Democritean atoms), but these relations are "external" to what those particulars are and have no constitutive role.

One consequence of a process metaphysics is that there are no particulars (Seibt, 2010, 2012; Campbell, 2009, 2015; Bickhard, 2015a). Instead, we find a *relationalism* of ongoing mutual influences among (ongoing) fields (processes). A metaphysically intrinsic relationalism precludes particulars: nothing exists or could exist in metaphysical isolation.

Note that, if there are not particulars, then there are no particular *events*. In turn, if there are no particular events, then *causality* is not a relation among such events. Thus, *action* cannot be modeled as the (causal) initiation of causal chains of such causal relations among events. Finally (for current purposes), models of *ethics* that are based on such causal chain models of action are at best badly framed and grounded (Bickhard, 2011). This is one, of many, examples of consequences that are induced by a different metaphysics.

Normative Emergence

Metaphysical Emergence

Within a process metaphysics, emergence is not a metaphysical mystery: it is a "natural" consequence of process organization (Bickhard, 2015a; Campbell, 2015).

The stabilities that are inherent in presumed particles and substances hold for those particles and substances themselves. However much particles might reconfigure or substances mix and remix, the particles and substances do not themselves change – and metaphysically *fundamental* particles and substances *cannot* change.

Among other consequences, this makes change prima facie difficult to model (reconfiguration and mixing are classical "solutions" to this problem), and it makes emergence impossible. There are no emergent fundamental particles or substances.[2]

The intuition of emergence is an emergence of some causally efficacious influence on the world in some "new" organization or configuration. But organization is *not* a particle or a substance and is, thus, not even a candidate for having emergent "causal" power (Kim, 1991, 1998; Bickhard, 2015a; Campbell, 2015).

On the other hand, if it is recognized that a metaphysics of process holds, then we find that all processes are organized and that whatever influence they have within the world is dependent in part on those organizations. Influences are essentially dependent on organization. So, organization *can* have "causal" influence; organization cannot be delegitimated as a potential locus or ground of "causal power" without eliminating "causality" from the world entirely.

The possibility of emergence follows "naturally" from a process metaphysics because "causally" efficacious influence of organization – which *is* emergence – is intrinsic to process metaphysics.

[2] This metaphysical assumption was at the core of the Parmenidean argument against change, an argument that began the Western assumption that change requires unchanging substrate (Gill, 1989; Campbell, 1992).

Normative Emergence and Thermodynamics

If process metaphysics clears barriers to an understanding of emergence per se, then it might enable a model of crucial *normative* emergence. Emergence of *non*normative phenomena, such as, for example, chemical valence, is itself blocked by a particle or substance framework, but *normative* emergence faces what appears as an additional challenge: Hume's argument against the possibility of deriving norms from facts (Hume, 1978).

Hume did not elaborate his claim, and much effort has been expended to try to construct such an argument for him (Schurz, 1997), but the basic claim is a background assumption for most in the contemporary Western world. If this claim were sound, then normative emergence would not be possible.

Hume's claim must be addressed if normative emergence is to be successfully accounted for.[3] I argue, however, that an understanding of Hume's position shows that it is based on a valid argument, but one that is unsound – it involves a false premise (Bickhard, 2009).

Hume's Claim. Hume "argued" that it "seems altogether inconceivable" that one could move from factual premises to normative conclusions in a valid manner (Hume, 1978, pp. 469–470). Much discussion of this has focused on what notions of deduction might support the argument (Schurz, 1997). I suggest, however, that considerations of *definition* make Hume's point clear: if there are terms in the conclusion that are not in the premises, then they must have been introduced (if the argument is valid) via definition. But definition has the form of some term or phrase being defined as equivalent to some other term or phrase, and such definitions permit backtranslations – every time a defined term occurs, substitute the defining term or phrase. This backtranslation might be iterated, but eventually the (presumably validly derived) conclusions will be backtranslated into terms available in the premises. Since those premise terms are, by assumption, all factual, the conclusion is also factual – not normative.

The problem with this reasoning is that not all valid definitions permit backtranslation. In particular, implicit definition does not (Bickhard, 2009). Hume did not know about implicit definition – it was introduced primarily in the late 19th century – but it is now a major part of model theory (Chang & Keisler, 1990).[4] Hume's notion of definition is derivative from Aristotle's abbreviatory form of definition, and in that framework, Hume's conclusion would seem to be both valid and sound. But, taking implicit definition into account, Hume's argument becomes valid but *un*sound: classical abbreviatory definition is not the only kind of definition, and implicit definition does not permit the backtranslation that yields Hume's conclusion.

Hume's argument, therefore, does *not* block the possibility of deriving normative conclusions from factual premises (or models). But this "brush clearing" of Hume's barrier to normative emergence also does not provide a positive model for such emergence. I address that now.

[3] Hume's argument is not generally addressed in discussions of models of normative function.

[4] Formally, a set of uninterpreted axioms *implicitly defines* the class of all of its models. There are also nonformal conceptions of implicit definition (Hale & Wright, 2000; Bickhard, 2009).

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Thermodynamics

The "unsoundness" of Hume's claim enables addressing a number of important emergences via thermodynamics – that is, a barrier (Hume's argument) is cleared that would otherwise seem to block accounts of emergence, including normative emergence. With that barrier removed, I turn to a model of normative emergence.

I claim that thermodynamics is central to models of *normative* emergence. Just as *stability* is the default for substance/particle frameworks, and change must be accounted for, so for process metaphysics, *change* is the default and stability must be accounted for. Process is inherently change, but process is also inherently organized, and organization may, or may not, involve various kinds of stability.

One kind of stability of process organization, for example, is what might be called "energy well" stability. Such stabilities are organizations that are in an "energy well" in the sense that the organization remains stable unless and until some above-threshold amount of energy impinges on them which disrupts them. That is, it requires additional energy in order for the process organization to change. An atom, a furious organization of quantum field processes, is a canonical example: it can remain stable for cosmic time periods unless hit by above-threshold energy.

Energy well stable forms will go to thermodynamic equilibrium if no energy impinges on them and remain stable in that condition indefinitely. Another kind of stable organization is quite different in that respect: far from thermodynamic equilibrium stabilities. Energy well organizations are stable even at equilibrium, but far from equilibrium organizations are *constituted* in being far from equilibrium: they cannot go to equilibrium without ceasing to exist. The stability of such process organizations requires continued *maintenance* of far from equilibrium conditions in order to counter the inherent tendencies toward equilibrium.

Self-Organization

One kind of emergence in far from equilibrium processes is that of self-organization. Far from equilibrium process can exhibit an inherent emergence of some further organization – perhaps spatial and/or temporal patterns, for example – within the basic process organization (Nicolis & Prigogine, 1977). A classic example is the self-organized emergence of boils of water in a pan of water heated from below – such "cells" of boiling water are not designed or induced externally but emerge naturally in such conditions. It is crucial to note that far from equilibrium conditions must be *maintained* in order for self-organization to be maintained – otherwise the process goes toward equilibrium and the self-organization ceases. If the heat is removed, the water boils disappear.

Self-Maintenance

A further kind of emergence – a further kind of complexity of self-organizing process – tends to counter that tendency toward equilibrium via the process itself *contributing* to the maintenance of the crucial far from equilibrium conditions. Such processes are, in that sense, *self-maintaining*. A canonical example could be a candle

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flame: the candle flame maintains its own above combustion threshold temperature; it vaporizes wax in the wick, making it available for combustion; it melts wax in the candle, enabling percolation up the wick; it induces convection in the air, bringing in oxygen and getting rid of combustion products – a candle flame makes a number of contributions to the maintenance of its own essential far from equilibrium conditions.

Autopoiesis. It should be noted that, although there are important convergences, this is not *autopoiesis*. Autopoiesis focuses on the self-construction of constituents. Autopoiesis *requires* far from equilibrium conditions (Di Paolo, 2005) but is silent about the *maintenance* of those conditions. Self-maintenance, in this model, is precisely the maintenance of the conditions of being far from equilibrium, and such relational maintenance might well involve *changes* in constituents and constituent relations, not just reconstruction of them. Consider an analogy with a balance scale, in which one pan is "system" and the other is "environment": maintenance of the relation of balance might involve changes in the "system" (e.g., the addition of weights), in order to compensate for change in the "environment" pan. Such changes in far from equilibrium processes such as an organism might involve, for example, learning and development within that organism in order to maintain self-maintenance within an environment – learning and development (or any other kind of adaptive change) are difficult to address within an autopoiesis framework (Di Paolo, 2005; Moreno, Etxeberria, Umerez, 2008; Moreno & Mossio, 2015). The focus on the autopoietic construction of components emphasizes the stable sameness of components over time, rather than the self-maintenance of the far from equilibrium *relationships* that are necessary for any such self "construction" – and maintenance of such relationships can involve (adaptive) changes in the organism itself.

Recursive Self-Maintenance

A further form of self-organizational emergence is *recursive self-maintenance*. A candle flame contributes to its own self-maintenance, but it does so in only one way: it burns, with multiple consequences. If the candle is running out of wax, for example, that candle flame cannot change its process in order to attempt to maintain its conditions in some other way. A bacterium, on the other hand, can do that. A bacterium can swim if it finds itself oriented up a sugar gradient, thus contributing to its own self-maintenance. But if it is oriented *down* a sugar gradient, then swimming is deleterious to its self-maintenance. The bacterium, unlike the candle flame, can alternate between swimming and tumbling in such a way as to primarily swim up such a gradient: it tumbles if oriented down, and swims if oriented up (Bickhard, 2009). To a first approximation, it detects when it is swimming down, then tumbles, then swims and checks again.[5]

Note that swimming is self-maintaining if oriented up a sugar gradient, but not so if oriented down that gradient. If oriented down, the tumbling contributes to self-maintenance. The bacterium can switch among alternative organizations of process in order to maintain the property of being self-maintenant: it self-maintains the property of being self-maintenant; it is *recursively* self-maintenant.

[5] Bacteria are more complex than this, but this approximation suffices for my point.

Autonomy

In general, self-maintenance and recursive self-maintenance ground a complexity of *further* emergent kinds of tendencies and maintenances of persistence. This graded hierarchy (and perhaps lattice structure) of further emergences collectively constitute *autonomy*. This is autonomy in the sense of being able to maintain in and make use of various kinds of environments, not autonomy in the sense of to be or become independent of those environments. This is an active, relational, and interactive sense of autonomy; an autonomous process makes use of environments in order to self-maintain.

Normative Function

Accounting for emergent normativity is crucial for multiple reasons, but one major reason is that mentality, in all forms, is saturated with many and multifarious normativities – from function/dysfunction to correct/incorrect representation to rational/irrational reasoning through ethic/unethical modes of being and acting. I will focus here on two grounding kinds of normative emergents: function and representing.

It is important to note that the focus here is on *normative function*, not machine functionalism or causal functionalism. Notions of function can be defined for machine and causal frameworks, but these are not normative:[6] it is at best difficult to account within such "machine" models for inherent normative *dys*function, such as a kidney not filtering blood well. There is no inherent "supposed to," no normativity, in a purely causal machine functionalism and, therefore, no inherent failure with respect to any such "supposed to." There is no causal machine equivalent of your kidney being "supposed to" filter blood, thus no dysfunction relative to that filtering "supposed to."

The basic model of function that I offer has already been outlined in the discussion of self-maintenance and recursive self-maintenance. In particular, contributions to self-maintenance are useful for – serve a function regarding – the persistence of the process organization. Serving a function, thus, is constituted most fundamentally as contributing to self-maintenance.

Etiological Models of Function. An important contrast here is with etiological approaches to modeling function, which focus on *having* a function, not on *serving* a function (Millikan, 1984, 1993). In general, in such models, an organ in an organism "having a function" is constituted in that organ having ancestors that were selected for performing that function[7], or some precursor to that function. I suggest that such selection histories may help explain how and why such a subsystem has come into – evolved into – existence, but that making such history metaphysically *constitutive* of

[6] Not normative for the machine itself, though there might be normative function for the user or designer of the machine. The computer has no stake in its transistors functioning "correctly," though you might. But an organism cannot be successfully self-maintenant if its kidneys are not functioning correctly – there is normativity for the organism itself.

[7] Or having the causal consequence that "becomes" that function when "sufficient" selections for it have occurred.

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having a function yields severe problems. One is that any other system that is "causally" identical to the biological system, but comes into existence in some other way, will not have functions because it does not have the requisite selection history. It will be causally identical to a system that has functions, but it will not have functions: etiological function is causally epiphenomenal. It makes no difference in how the world works (Bickhard, 2009).

In contrast, successful or unsuccessful contributions to self-maintenance do not have an etiological metaphysics, even if they may have an evolutionary etiology, and they do make a difference in how the world proceeds: they are not epiphenomenal. This model, then, does not encounter the problems of epiphenomenalism.

The focus on serving a function – contributing to self-maintenance – rather than on having a function does issue a promissory note, however: how to account for *having* a function within this framework. The model of *having* a function is based on the point that successful serving of a function depends on enabling and supporting conditions, that may or not hold. For example, a candle flame will not be successfully self-maintenant if the wind is too strong. In an organism, many functions have to be served in order for overall self-maintenance to succeed. Any given organ will serve its function(s) if other supportive conditions are maintained by other processes in the organism. In that sense, the focal organ functionally *presupposes* that these supporting conditions are themselves maintained, in general by other parts of the organism. In that sense, other parts of the organism *have* the function(s) of maintaining the supportive conditions – they have those functions in the sense that they are presupposed to serve them.

Agency and Development

Interaction and Agency

The swimming and tumbling interactions of the bacterium are a simple form of agency. One salient functional characteristic at the level of the bacterium is that the alternative forms of interaction are, to a first approximation, simply triggered – if certain conditions are detected[8], certain interactions are engaged.

In more complex agents, such as a frog, triggering does not suffice. There may be multiple possible interactions the frog could engage in in any particular circumstances. Perhaps it could flick its tongue in one direction and eat, or a different direction and eat. Such possibilities may be multiple and must be *indicated* for the frog in branching functional indicators of such possibilities. That is, for complex agents, indicating what interactive possibilities obtain is a functional necessity (Bickhard, 1980a, 1993).

A further form of complexity is for such indications to iterate, in the sense that engaging in some of them may create the conditions for others to be accessible. For the frog, for example, there may be an indication that if the frog were to move a little to the left, further tongue flicking and eating possibilities would come into range.

[8] It is important to note that such detection need not, and in the case of bacteria does not, constitute representation of what is detected. Conflating detection and representation is a common error in the literature.

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Branching and iterating indications can integrate into complex webs of interaction possibilities and dependencies. I call such webs of interaction possibility *situation knowledge*: they constitute the organism's (interactive, pragmatic) knowledge of what it could engage in from within its current situation.

One necessary function with regard to such situation knowledge is that of *selecting* what interactions, and interaction paths, to actually engage in. This can be a complex process, but it constitutes in general processes of *motivation*.[9]

A crucial property of such indications of interaction possibility is that they can be true or false – they have *representational truth value*. That is, an indicated possibility may or may not be in fact possible: the indication may be false. This is the ground form of representing.

Furthermore, if an indicated interaction is engaged in and it does not proceed as indicated, then it is falsified in a manner potentially functionally accessible to the organism itself. Error is *organism detectable*.[10]

This is a model of representing as being constituted in having *truth value*, not in terms of correspondence. Correspondence models have fatal errors that have bedeviled attempts to understand representation for millennia (Bickhard, 2009, 2014). Representing in terms of truth value is an alternative that avoids the problems with correspondence models (Bickhard, 2009). These problems with correspondence models have yielded large families of critiques of "representation" as correspondence, often yielding the conclusion that representation does not exist. I have contributed myself to that large and growing family of critiques (Bickhard, 1980a, 1993, 2009, 2014), but I do not conclude that representation does not exist – the conclusion that representation does not exist is a non sequitur: it presupposes that correspondence is the only way to model representation, and that is incorrect. The non sequitur is akin to concluding that, since phlogiston does not exist, therefore fire must not exist.

Conversely, many, if not most, of the critiques of correspondence models turn on the point that such models cannot account for truth value (e.g., how do you get truth value out of causal or informational correspondence?). Representing as future-oriented indications or anticipations does not have this problem: instead of looking backward down the input stream to try "see" where it originates (Dewey, 1960/1929; Tiles, 1990), future anticipations "wait" to find out what the future (of an interaction) actually produces.

Affordances. Indications of possible interactions have strong similarities with Gibson's affordances. Within at least one interpretation, that is exactly what affordances are. But Gibsonians often do not want to consider that affordances may not only branch, but also iterate, and form complex webs, and certainly not that they might have truth value – that sounds too much like (mental) representation. So, there is a kinship with the notion of affordances, but not with the antipsychologism that often accompanies it.

[9] Motivation is at times considered to be an energizing of the organism to do something rather than nothing. But organisms never do nothing: if they do, they are dead. Motivation is the selection of what to do, even if it is to sleep, not an energizing out of a default "nothing" (Bickhard, 2000, 2003).

[10] Organism detectable error is necessary for error-guided interaction and learning, but it is impossible to account for organism detectable error in standard encoded correspondence models of representation (Bickhard, 2009, 2014).

Epistemological Constructivism

This is a model of emergent representing in terms of future-oriented anticipations of an active and interactive agent. There is no passive mind, into which the world impresses itself. There are no signet ring impressions into the wax of the mind, no blank slates, no transduction, no induction.

Agency system organization *must* be constructed: it cannot be (im)pressed (Bickhard, 1992a).[11] Absent prescience for those constructions – foreknowledge of what would work – this forces a trial and error, a variation and selection, constructivism. This forces an evolutionary epistemology (Campbell, 1974). Such constructions can occur most simply as a result of various forms of self-organization[12], but also via more complex constructive processes.

A kind of constructivist model can be built on a passive mind model, with the positing of some base of constructivist atoms, perhaps innate, with constructions consisting of combinations of such foundational atoms (e.g., Fodor, 1975, 1981). Versions of such a model are in fact dominant in contemporary developmental psychology, with various controversies about whether that foundational base is strictly perceptual or necessarily includes conceptual atoms. But any such foundationalism is itself ultimately incoherent, and some sort of emergent constructivism is necessary (Allen & Bickhard, 2011) – e.g., how did evolution manage to create Fodor's foundational representational atoms, or anyone else's foundational representational atoms? And why cannot learning and development do the same? Representing has to have emerged since the Big Bang[13], so some process has to be capable of yielding such emergence, and there are no models of how evolution could accomplish this while learning and development could not. The problems intrinsically involved in such foundationalist models permeate from metaphysics all the way down to methodology and experimental design – as mentioned before, if a framework is presupposed that precludes emergent constructivism, then there will, in general, be no control conditions for constructivist alternative hypotheses. This is the status of large swaths of current developmental literature (Allen & Bickhard, 2013).

Learning and Development

Constructivism within an interactive model is not necessarily the same as constructivism as conceived of with a ground of atoms – construction does not necessarily consist solely of combinations of (atomic) units. In particular, self-organization can induce reorganizational constructions that are not renderable in terms of combinations of atoms. This might involve, for example, changes in coupling strengths among processes, alterations in dynamic spaces, perhaps even attractor landscapes, and so on.

[11] An interactive organization competent to interact with some (kind of) environment will not in general have *any* structural correspondence with that environment. E.g., a simple feedback loop can be competent to many different kinds of task structures. So, the naïve metaphor of structural impression, interiorization, or internalization, is misguided (Bickhard, 2009).

[12] There needn't be a "constructor."

[13] Unless we posit a dualistic metaphysics in which such normative phenomena are in some sense brute and dirempted from the "natural" world, but this raises a multitude of further problems inherent in such dualisms.

If such reorganization is evoked by failure of interactive processes to successfully anticipate, and, conversely, if process organization is stabilized by anticipatory success, we have a simple variation and selection model of learning. Organization is what varies and what is selected.[14]

Such reorganizational construction is characteristic of simple nervous systems, but there are more complex forms of construction that can emerge within such kinds of processes.

One would be a *recursive constructivism*, in which prior constructions can serve either as units for further construction or as loci within which further reorganization can occur. One further step of complexity would be a *meta-recursive constructivism* (Campbell & Bickhard, 1992) in which not only the realm in which constructions occur is recursive, but also the realm of the processes that induce and engage in such construction – the construction processes are themselves recursively constructive. It is to be noted that Piaget's notion of *equilibration* is recursive, but not meta-recursive – but more complex agents, including human beings, seem clearly capable of meta-recursive learning: learning to learn.

In general, there is *one* general realm of construction, that can take various forms and complexities – learning and development are *not* differing processes. *Learning*, in this model, is constituted as the (study of the) dynamics of such constructive processes. Recursive and meta-recursive processes involve further emergent properties that form the core of *development*. For example, for a recursive constructive process, certain prior constructions may be functionally required in order to enable later constructions: some constructions may be too complex in their full competent form to be constructed in one constructive step but can be reached by partial successful constructions that create a stepping-stone pathway to the full competence. Development studies such enablings and constraints in constructive paths and trajectories (Bickhard, 1992b; Campbell & Bickhard, 1992).

Trajectories of potential construction can inhere in the nature of a domain, such as algebra being required to learn calculus, or in the nature of the constructive processes themselves (Campbell & Bickhard, 1992). But such construction trajectories can also be enabled via intervention in the environment, by, for example, reducing or eliminating selection processes so that constructions that might not be successful with respect to a full task realm can nevertheless be successful in a reduced-selection environment and thereby serve as stepping points on the way to fully competent constructions (or at least constructions that survive full selection processes). In this way, a developmental trajectory can be *scaffolded* via such blocking of selections. This is a noninternalization, noninteriorization model of scaffolding. One consequence of such a model of scaffolding is that it is possible for a person to block or mitigate selection processes for their own learning and development[15] – *self-scaffolding* makes clear sense, whereas someone providing to themselves knowledge for internalization that they do not already have makes no sense: it is contradictory (Bickhard, 1992b).

[14] Not configurations of (representational) atoms.

[15] E.g, breaking problems down into subproblems; moving to ideal or approximate cases; relying on external supports, such as an attachment figure, that may not be required for later development, and so on (Bickhard, 1992b).

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Reflection Constraints on Development. One major constraint on developmental constructive processes is that of *reflection*.[16] In particular, a construction involving reflection cannot occur prior to the construction of what is being reflected upon: there is an intrinsic constraint on constructive trajectories here.

Reflection enables many developmental trajectories, but a central question is what enables reflection itself, and when in development does this occur? It seems unlikely that frogs are capable of reflection, but humans are, so this capability evolved. It is an empirical question both when it evolved, and when it is enabled in human development. I will not address here when it evolved (it is/was likely a slow gradual process; see, e.g., Bickhard, 1980b), or how it is realized in the brain (see Bickhard, 2015b, 2015c). But there is strong empirical support for the age of about 3.5–4 years for when it is enabled in human development: virtually every domain of development manifests an "age 4" shift that is modelable in terms of the advent of reflection (Allen & Bickhard, 2018; Bickhard, 1992d).[17]

One of the stronger indications of this shift is a test that was specifically designed to differentiate reflective capabilities from lack of such capabilities. This is called the leaning-blocks test, and it too indicates a shift at about the age of 4 (Allen & Bickhard, 2018). It is nontrivial to test for reflection, among other reasons because many tasks that prima facie seem to require reflection in fact do not, and because reflection, if it is enabled, can often be "used" to address tasks, even if it is not strictly required for those tasks (Bickhard, 1980b, 1992d).

In any case, reflection is an important example of a general constraint on development (Campbell & Bickhard, 1992). It induces a kind of stage structure in the possible trajectories of development: some constructions involve reflections on prior constructions and, thus, cannot precede those prior constructions (Campbell & Bickhard, 1986).

Microfunctional Brain Processes

It is interesting, and consilient, and important, to see how such anticipatory processes are realized in the brain. If they are not, or could not, be so realized, then the model is false. Furthermore, the manner in which such anticipatory processes are realized is strongly consistent with what we know about how the brain actually functions, while alternative models are not consistent. So, seeing how they are in fact realized requires, first, that the common model of brain functioning – in terms of classical synapse connections among neurons processing "information" via threshold switch processes – be recognized as empirically false[18] and a more realistic model of brain functioning be outlined.

[16] This is related to Piaget's reflective abstraction, but not necessarily identical to it. Part of the issue here is that Piaget's notion of reflective abstraction was itself evolving over the course of his work (Piaget, 1977/2001; Campbell & Bickhard, 1986; Campbell, 2001).

[17] All reflective constructions are subject to the "no reflection without something to reflect upon" constraint, but, given that reflection as a domain-general process is enabled (age 4), more specific reflective constructions do not necessarily involve domain general enabling constraints. The basic "no reflection without something to reflect upon" constraint can apply *within* a developmental domain (Campbell & Bickhard, 1986), and, thus, the reflective "stages" or levels in such trajectories do not necessarily manifest age synchrony across domains.

[18] As well as conceptually incoherent. I will not address the incoherence per se here. This has been argued for decades, if not millennia; there have been no real answers to these criticisms, but the framework remains dominant, in multiple forms, mostly because of a lack of alternatives. I offer the interactive anticipatory model as such an alternative (Bickhard, 2009, 2014).

Microfunctioning in the Brain

Common models of brain functioning are in terms of some version of threshold switches in complex structures that process semantic information, with neurons influencing other neurons via synapses. Perhaps the closest to classical threshold switch neurons in the brain are integrate and fire neurons – inputs are integrated and the integration *modulates* firing. Deviation from "standard" models is already present in this point: neurons can have multiple nonzero baseline rates of firing, so the modulations from inputs do not necessarily constitute switches above or below threshold. In fact, some neurons *never* fire: silent neurons (Bickhard, 2015b). This makes no sense within the frameworks of standard models. Still further, neurons modulate each other's activity not only via synapses, but also via gap junctions, which are essentially pores in the neural cell walls that overlap from one neuron to another and directly exchange ions and other modulators.

Another important aspect of brain functioning is the existence of volume transmitters and neural modulators. In general, neural "transmitter" substances may or may not remain constrained to a synaptic cleft. To various degrees, "transmitter" substances can diffuse into intercellular space, modulating the activities of potentially large populations of neurons. Some synapses are intrinsically open to volume transmission, and this "openness" may itself be variable and modulated. Other cases may be *entirely* a matter of volume transmission, with modulators being released directly into intercellular space (Bickhard, 2014, in preparation).

And then there are astrocytes – a form of glia – that play an essential set of roles in brain functioning. Astrocytes have receptors for "transmitter" substances and release such substances as volume "transmitters." They have gap junctions with other astrocytes and engage in calcium waves across populations of astrocytes, thus modulating each other.

Astrocytes also modulate synaptogenesis – the formation and dissolution of synapses[19]. They also modulate neurogenesis. Astrocytes have centrally important influences on neural functioning; they are part of how the brain functions. Threshold switch models are false even about neurons per se, and neurons are not the only functionally relevant cell types in the brain – astrocytes are also functionally relevant.

A further mode of astrocyte functioning is that they can form "bubbles" that encompass populations of neurons. An astrocyte can have influences on the concentrations of "transmitter" substances and ions within its enveloped space and, thus, alter the intrinsic functioning of the neurons within that space. This constitutes a kind of dynamic system "programming": such modulations change the parameters of local intrinsically active processes, thus altering the dynamics that those processes will engage in, and such parameter setting is the dynamic system equivalent of "programming." So much for threshold switch models.

Neurons are not passive, any more than the brain itself is passive. They are constantly ongoingly active. For neurons, this activity is, in general form, that of oscillation, with the various kinds and degrees of modulation being modulations of such oscillatory activity. Modulation of oscillation is the basic functional form in the brain, not threshold switching.

[19] Synapses are not permanent "hard-wired" connections. They are, *if stable*, steady states of process of formation and maintenance, and they are not necessarily stable at all.

Microanticipatory Processes: Microgenesis

So, the brain, at local levels, manifests larger-scale processes, such as astrocyte processes, that modulate smaller-scale processes, such as synaptic and neural oscillation processes. Within an astrocyte "bubble," the relative commonality of the within-bubble environment induces weak coupling among the oscillatory processes at the smaller (thus faster) scales. Weak coupling among oscillatory processes is a way of inducing attractor landscapes in the dynamics (Hoppensteadt & Izhikevich, 1997; Bickhard, 2015b, c), and, so, changes in the parameters of such weak coupling can induce a dynamics of the attractor dynamic landscape itself. That is, larger-scale, slower processes can modify and influence the dynamic spaces within which the smaller, faster, processes take place. This is a powerful form of dynamic "programming."

There is much more to be elaborated about these dynamic relationships, but for current purposes, this point about a dynamics of dynamic spaces suffices. In particular, the slower processes that induce (changes in) faster process dynamic spaces are *setting up* – preparing – those faster processes for near-future activity – a kind of *microgenesis* of modes of activity. That set-up may be successful or not: the dynamics that are "set up for" in this way may or may not be able to accommodate what actually transpires in the ongoing interactive processes.

The key point for current purposes is that such microgenesis is anticipatory: it functionally anticipates the course of activity in the sense of being "prepared" in its dynamic space(s) to engage (some range of) the future course of processing. This anticipatory character entails that there is emergent truth value: the anticipations are correct or not correct, true or false.[20]

Theoretical considerations, thus, lead to the conclusion that there must be anticipatory processes in the brain, and this is in fact what we find realized. Conversely, the empirically discovered facts concerning brain microfunctioning yield a model of microgenesis that is intrinsically anticipatory. The theoretical and the empirical are mutually supporting and mutually implying – a strong relationship.

Learning and Development, Again

As mentioned in a more general manner earlier, if microgenesis destabilizes with anticipatory failure and stabilizes with success, we have a basic evolutionary epistemological model of learning – learning of processes that have truth value, and, thus, the learning of representing. Insofar as this model of representing and the learning of representing can be elaborated to model more complex cognition and construction, we have a ground for cognition and cognitive development more generally (Bickhard, 2009; Campbell & Bickhard, 1986).[21]

[20] Anticipations of possible interactions will be true qua anticipation, in general, in some circumstances but not in others. So, such an anticipatory indication functionally presupposes that such supporting, enabling conditions hold. This realm of functional presuppositions provides a model of representational content (Bickhard, 2009).

[21] There are, in fact, many further such emergences that have to be addressed within this framework – many further kinds of normativity that must be modeled. These include, for example, reason and rationality; emotion and reflection are still further emergences (Bickhard, 2000, 2015c). Beyond these are social ontologies, including language and persons, personality and psychopathology, and ethics (see, for example, Bickhard, 2009, 2011, 2013).

Conclusion

A process metaphysics yields ontological emergence as a "natural" kind of phenomenon in the world – including, in particular, normative emergences. Mentality and personhood are saturated with, and constituted in, such multifarious normativities. These include function, representing, rationality, action, social ontologies, personhood, language, and ethics. Multiple other phenomena emerge as specializations of, elaborations of, and aspects of these basic kinds of phenomena, e.g., perceiving, memory, motivation, and so on.

We cannot understand psychological phenomena, and the development of psychological processes, without understanding the nature and origin of these emergent normative processes, and we cannot understand emergent normative processes without a process metaphysical framework that can account for emergence and normative emergence. Substance, structure, and particle metaphysics cannot enable such models, and, thus, make understanding such processes impossible. Conversely, a process metaphysical framework, strongly supported on independent logical and scientific grounds, enables models of emergence, and, in particular, of normative emergence. And this opens the way to understanding the myriad normative phenomena that constitute mind and development within an integrated naturalism – integrated via emergence that undoes the diremption between fact and norm, between "cause" and reason.

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