CHAPTER

5

The Biological Emergence of Representation

Mark H. Bickhard
Lehigh University

NATURALISM AND EMERGENCE

Emergence is a difficult and sometimes contentious issue. What is at stake? On one side, what is at stake is the success of naturalism, of understanding our world as being constituted of integrated natural phenomena. Many kinds of phenomena have, at various points in history, been considered to be exceptions to a naturalistic framework, and to instead require specific substances to be postulated that interacted with the rest of the world, but had no deeper relationships. That is, they have been thought to require a dualism, or higher multiplicity, of fundamental ontological kinds. Fire, life, magnetism, heat, and so on were all once thought, at least by some, to be due to their own dedicated substances—phlogiston, vital fluid, magnetic fluid, caloric, and so on—but are now understood as emergent phenomena of particular kinds of natural processes. Naturalism is now a basic assumption of the scientific enterprise, though it is much easier to espouse naturalism than it is to develop models that are consistent with naturalism.[1] I argue, in fact, that con-

[1]Naturalism is often and all too easily equated with some kind of physicalism or scientism. I use the term to refer to a kind of regulative ideal that presupposes an integrated world in which further questioning is always appropriate. Empedoclean earth, air, fire, and water, for example, constituted an advance over simpler categorizations, but also blocked inquiry: One cannot ask about the origin of such basic substances, for an explanation of their properties, and so on. The same can be said for the many modern equivalents of such substance assumptions (Bickhard, in preparation; Bickhard & Christopher, 1994).

temporary models of function and representation fail the standards of naturalism and I offer alternatives that meet those standards.

Phenomena that remain unintegrated into the naturalistic world view today are primarily kinds of normative phenomena. Function, representation, rationality, and ethics are all examples of normative phenomena for which we have no consensual naturalistic models, and for which some would argue no such models are possible. The claim that normative phenomena cannot be addressed naturalistically is sometimes made with the slogan "You cannot derive ought from is," that is, the claim that one cannot derive norms from facts.[2] A failure of naturalism here would introduce some kind of dualism for mental phenomena and perhaps also for biological normative function as well.

On the other side, emergence is also deeply involved in contentious issues *within* the framework of naturalism. In particular, one could propose a naturalism in which emergence did not exist and everything that we take as seeming to be emergent would be proposed for some kind of eliminative reductionism. Such an eliminative reductionism has been proposed for much of the mind: Only brain processes are real and all appearances to the contrary are *merely* appearances (Churchland, 1986; Churchland, 1989).

More broadly, however, if naturalism holds, but emergence does not exist, then most of our familiar world—rocks, trees, other people, our own minds—is at best epiphenomenal, not really causally efficacious in the world, and at worst fictitious, simply illusions. The only reality is that of fundamental physical particles. It is difficult to take such a possibility seriously, especially for our own minds, but science has certainly made a case for strongly unobvious and counterintuitive results before, and there are powerful arguments to that effect for emergence.

A less personal but more directly scientific issue that is at stake is that many kinds of phenomena, whatever their status as *ontologically* emergent (or not), clearly once did not exist in any form (e.g., at the time of the Big Bang) and do now exist. Any model of such phenomena that makes such emergence, whether epiphenomenal or not, impossible thereby cannot account for the existence of the phenomena at all. This can serve as a strong critical consideration when evaluating models, such as those of representation, because many current models fail that test of the emergence of novel phenomena.

This point raises issues about what emergence is. Is it mere novelty, or is, for example, causal efficacy required? Again, there is no consensus. Emergence involves new properties or entities "emerging" at new levels of organization, but there have been many proposals concerning just exactly

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[2]See Bickhard (1998, in press-b) for a reply to this argument against the emergence of normative phenomena.

what emerges (e.g., properties or entities, must they be causally efficacious, etc.), how such emergence can be understood, and what counts as a relevant "level." The British emergentists earlier in this century–Broad, for example–proposed that certain natural laws applied only when particular kinds of organization came into existence, but, in any instance in which those critical organizations did exist, the laws had full effect. These laws were thought to be natural, and therefore in that sense did not violate naturalism (though they did violate the anti-ad hoc spirit of naturalism), but were not derivable or predictable from any of the constitutive entities or processes that participated in the critical organizations. One of the primary examples of the British emergentists was chemical valence and, when quantum mechanics was able to explain valence without recourse to such ad hoc laws, British emergentism faded (Stephan, 1992).[3] Nevertheless, such a strong version of emergentism still serves as a backdrop for many contemporary discussions in the form of claims that anything that is derivable from lower level considerations cannot count as emergent.

The notion of emergence began as a reference to phenomena that could not be explained as *additive* consequences of underlying phenomena (Stephan, 1992). Non-additivity has remained an important consideration, but additivity versus non-additivity, or linearity versus nonlinearity, is not sufficient to address the basic issues of epiphenomenality or eliminative reduction. If, for example, all causality were resident in fundamental physical particles (as will be discussed later), then whether the causal dance of those particles was additive or non-additive, linear or nonlinear, would be irrelevant to the point that all causality would be resident in those particles, not in any higher level that was composed out of those particles. All apparent higher level 'causality' would be epiphenomenal.

Few would reject the claim that new causal regularities can occur in particular kinds of underlying system organization. The emergence issues turn on whether these regularities constitute emergence in any metaphysically important sense, in particular, whether mind can be understood as being more than just a (nonlinear) regularity of underlying nonmental processes, that is, if mind is merely epiphenomenal.

A deeply related issue is that of downward causation. If genuine non-epiphenomenal emergence does occur, then it ought to not only be manifested in causal consequences at the level of the emergence and at higher levels, but it also ought to have consequences at lower levels. That is, we should find downward causation from emergent phenomena (Campbell,

[3]Piaget rejected emergence (Kitchener, 1986), but his conception of emergence seems to have been that of the British emergentists and his grounds for rejection do not hold for other conceptions of emergence. In fact, Piaget's entire *oeuvre* can be seen as an attempt to model the biological emergence of cognition and rationality within a generally naturalistic framework (e.g., Piaget, 1971).

1974a, 1974b, 1990). A classic purported example is the downward causal influence on the molecules making up a soldier termite's jaw—which is too large for the termite to even feed itself, therefore requiring constant tending by nest mates—from the higher level social and evolutionary processes of the termite species and nest. A closer-to-home example would be whether or not mind makes any causal difference at all in the physical processes at lower levels that we associate with presumably mental organisms, such as ourselves.

KIM'S ARGUMENT

I do not attempt to address all of these issues here. I do address, however, one of the strongest arguments against causally efficacious emergence, that of Jaegwon Kim (1993a, 1993b, 1997, 1998). I choose Kim's arguments not only because they pose one of the strongest challenges to any concept of emergence and any model of purported emergent phenomena, but also because Kim, in my judgement, has discovered in his argument a *reductio ad absurdum* of important standard assumptions. That is, I argue that Kim's argument does not ultimately hold, but that avoiding it requires important shifts in other common assumptions. In particular, it requires abandoning the substance and structure assumptions that are ubiquitous in contemporary psychology (Bickhard, in press-d; Bickhard & Christopher, 1994).

Kim points out that we seem to be faced with a dilemma: Either all causality resides in the fundamental physical particles and all higher level phenomena are just the working out of the causal interactions at this basic particle level, or something that is not part of fundamental physics has causal influence. In the first case, everything above the fundamental physical particles is causally epiphenomenal. In the second case, the universe is not physically closed, and naturalism is false.

The crucial move in this argument is that, whereas emergence is intuitively a product of higher level organizations of lower level processes and particles, Kim's argument points out that such organization is merely the framework within which the particles engage in their causal dance. Such organization cannot contribute any causal power itself—all causal power is resident in the particles. But, since organization cannot be a legitimate locus of causal power, there is no way in which any higher level emergence can have any causal power. The only properties in the higher level that are novel are the organizational properties, but if organization has no possibility of causal power itself and is restricted to being just a stage for the working out of fundamental particle causality, then all higher level phenomena are at best causally epiphenomenal.

Particles themselves, on the other hand, have no organization. They can *participate* in organizations of processes of interacting with other particles, but no fundamental particle itself has organization—otherwise it would not be fundamental. This point is the flip side of the ineligibility of organization as a possible locus of causal power: Organization is the framework within which particles, which have no organization, can work out their interactive causal consequences. Therefore, organization cannot be the locus of causal power and no higher level organization can manifest more than causally epiphenomenal "emergence."

But particles and organization are all there is. In particular, if organization cannot constitute a locus of causal power, then causally efficacious emergence cannot occur *unless* causal power resides in more than basic particles. But then naturalism takes a serious blow because reality would not be physically closed; something not part of the physical realm of basic particles would influence physical processes.

I find this argument to be valid, but unsound. I have argued that the critical move is the diremption between organization and locus of causal power (Bickhard, 2000b; Campbell & Bickhard, in preparation). Particles have no organization but do have causal power, while organization must be merely the framework for working out particle causal consequences, or else naturalism fails. The incorrect assumption in this reasoning is the assumption that the physical realm is constituted by particles interacting in space and time.

In fact, our best current physics shows that there are no particles, none at all (Brown & Harré, 1998; Cao, 1999; Davies, 1984; Saunders & Brown, 1991; Weinberg, 1977, 1995–2000). All of physical reality is composed of quantum field processes and the appearance of particles is a manifestation of the quantum nature of the field processes. But that quantum nature, in turn, is no more a manifestation of individual particles than is the quantization of the number of wave lengths in a guitar string—there are no "guitar sound" particles. The number of manifest particle interactions is not even an invariant, but will vary from one observer to another.

This shift to a field framework is of fundamental importance for the issues at hand. Field models are process models, not particle models. The crucial characteristic of process models, including (quantum) field models, is that there is *nothing* that does not possess organization. Everything has organization; it is not just that everything *participates* in organization, but that everything *has* organization. In particular, all quantum field processes are inherently organized. They cannot exist without organization; they cannot exist at a single point.

But if everything is inherently organized, if process organization is constitutive at all levels, then it is not legitimate to delegitimate organization as a possible locus of causal power. If everything has organization, then anything that has causal power will have organization. Furthermore, the causal properties will vary depending on such organization: Organization has causal potency. Conversely, if organization is rejected as a legitimate locus of causal power, then *nothing* has causal power.

Moreover, this point holds at all scales. Quantum phenomena such as superconductivity, for example, can occur at any scale, so it is not possible to specify a scale below which organization might have causal power, but above which organization would be merely a framework for working out lower level causal powers.

Finally, if organization cannot be precluded from carrying causal power, then higher level organization cannot be precluded from manifesting new, nonlinear, emergent causal power. After all, all higher level organization is "just" a potentially very complex quantum field organization, and quantum field organizations are all there is. So, if something, *X*, is ontologically constituted as a kind of organization of (quantum) processes, then whatever the causal properties are of that organization, they are the causal properties of what that organization constitutes. They are the causal properties of *X*, nonepiphenomenally.

The move from a particle metaphysics to a process metaphysics, then, undercuts Kim's arguments. In effect, Kim has discovered a *reductio ad absurdum* of particle metaphysics. Such a metaphysics makes emergence impossible (or forces a violation of naturalism). Conversely, any naturalistic theoretical framework that is committed to a particle metaphysics cannot account for emergence, and is thereby committed to an eliminative reductionism.

Of what relevance is this for issues in psychology? It is deeply relevant. Much of psychology is still committed to various kinds of atomisms or substance models. That is, much of psychology is still not developed within a process metaphysics and, therefore, cannot account for the emergence of basic psychological phenomena. But, if such models cannot account for the *emergence* of psychological phenomena, then they are likely to be poor models of the *nature* of such phenomena. Phlogiston could account for some properties of fire, but failed miserably to account for its basic nature and could not address many properties of fire that emerged naturally within a model of fire as a process of combustion.

PRAGMATISM AND PIAGET

Failures to be consistent with naturalism can be subtle, not perspicuous at all, and are therefore an easily committed error even for those who espouse naturalism. This is also true for failures to account for emergence. The first caution for both issues is to proceed within a process metaphysics. Otherwise, one is committed either to a nonnaturalism or to a strong reductivism.

Pragmatism is a philosophical orientation that is deeply committed to a process metaphysics and, therefore, is a candidate for naturalistic investigation, especially for studies of mental phenomena. Pragmatism introduced novel ways of conceptualizing representation and mind that offer possibilities of avoiding millennia-long aporia in standard approaches (Joas, 1993). Piaget worked within a generally pragmatist framework—the influence included the line from Peirce and James through Baldwin to Piaget—and is therefore among the few psychologists to explore an orientation that might ultimately succeed in naturalizing the mind. Most of psychology is still dominated by traditions extending back to the ancient and classical Greeks, by what pragmatists have dubbed "spectator" models of representation, in which perception and cognition are matters of passive receipt of impressions from the world (Smith, 1987).

I will pursue the Piagetian programme of modeling the nature and emergence of representation within a process, a pragmatist, framework. With respect to mental phenomena, the most important manifestation of a process orientation is the shift from passively conceived perception as the metaphor for mind to an understanding of action as the proper framework for modeling mental phenomena (Joas, 1993). This commitment to action as the fundamental framework is one of the most important aspects of Piaget's work, but one whose importance is at times underappreciated even by Piagetians.

I approach the model of representation via the initial emergence of normative function, with representation constituting a further emergence for serving a particular kind of function. Along the way, I address some of the alternative models on offer, arguing that they fail the criterion of accounting for the naturalistic emergence of these phenomena.

FUNCTION

Some processes are fleeting, such as the fall of a leaf. Some patterns or organizations of process, however, can be stable, perhaps even for cosmological lengths of time. One major kind of such stable patterns of process is that of energy well stabilities. A pattern of process that is persistent due to an energy well stability is one in which the process is in some (local) energy well and would require an input of energy sufficient to raise its energy level above some threshold in order to change its pattern. Much of the basic furniture of the world is constituted by such energy well stable process patterns, such as atoms, molecules, rocks, and so on.

Another kind of stability of process is exhibited by certain far-from-thermodynamic equilibrium processes (Nicolis & Prigogine, 1977). Far-from-equilibrium processes require ongoing interactions and transactions with their environments in order to maintain their far-from-equilibrium conditions. In some cases, maintenance of these conditions depends entirely on external stabilities—a chemical bath maintained in far-from-equilibrium conditions will depend on the external conditions of the chemical containers remaining nonempty, the pumps continuing to work, the electricity for the pumps (and perhaps a stirrer) continuing, and so on.

Self-Maintaining Systems

There is a special kind of far-from-equilibrium process, however, that can make its own contributions to the maintenance of its own far-from-equilibrium conditions. One simple example is a candle flame: It maintains above combustion threshold temperature; in a standard atmosphere and gravitational field, it induces convection, which maintains a supply of oxygen and removes waste products, and so on. These are called *self-maintenant systems*. I propose to model the emergence of function in terms of self-maintenant far-from-equilibrium systems.

Serving a Function

The basic point is simple: The contributions that a self-maintenant system makes to its own stability constitute functions that are being served relative to that system. The property of being self-maintenant is a natural property and has causal efficacy in that the continuance (or lack thereof) of the far-from-equilibrium process makes a causal difference in the world. It is an emergent property in the sense that it emerges in particular organizations of process and cannot be reduced to properties of any of its parts. In fact, it may not have any stable parts: Far-from-equilibrium systems are necessarily open systems and the components of the process may completely change over time. Neither the fuel nor the oxygen nor the combustion products remain constant in a candle flame.

This notion of serving a function is relative to the system to which contributions are being made. The heart of a parasite, for example, may be functional to the parasite, but dysfunctional to the host.

Function is normative, in the sense that conditions of success and failure are involved.[4] A kidney may have the function of filtering blood by virtue of

[4]There is also a form of functional analysis, sometimes called *causal role analysis*, that focuses on the causal contributions made in a system to some outcome or property of interest to the observer doing the analysis (Cummins, 1975). There is no inherent normativity in this notion of function: All normativity is resident in or derivative from the purposes and interests of the individual doing the analysis. In both normative and nonnormative senses of function, some selection is being made among the actual or typical causal consequences as being causal consequences that are functionally relevant. A heart pumps blood, makes heartbeat sounds, and contributes to body weight, but only the pumping of blood is functional.

being an instance of a kind, a type, of a part of an organism that normally serves that function, even if this *particular* kidney fails to serve that function, even if it is dysfunctional.[5] Furthermore, serving a function is normatively asymmetrical to being dysfunctional precisely in the sense that serving a function tends to serve the stability of the system, whereas being dysfunctional debilitates that stability. That is, serving a function is normatively positive for the system at issue.

Etiological Approaches

The dominant models of function today are etiological (Godfrey-Smith, 1993; Neander, 1991). They attempt to model the nature and emergence of a part of a system having a function in terms of the history of predecessors to that part, the evolutionary history in particular. Kidneys have the function of filtering blood, in this view, because their evolutionary predecessors were selected for accomplishing that causal process. That is, this kidney is here, it exists, because of the evolutionary history of filtering blood of predecessor kidneys: Thus, the "etiological" model.

Etiological models have at least one counterintuitive consequence that I focus on because, I maintain, it reveals a deep problem: a failure of naturalism. Millikan (1984, 1993) points out that, in the science fiction case in which a lion suddenly popped into existence that was molecule for molecule identical to a lion in the zoo, the organs of the science fiction lion would not have any functions, whereas the organs of the zoo lion would have functions, in spite of the (by-assumption) molecular level identity between the two lions. The difference is that the science fiction lion and its organs would have no evolutionary history and, therefore, certainly no relevant evolutionary history, for its organs to have functions.

This example is just a particularly striking version of the more realistic point that, the first time some organ or process produces a useful consequence, that consequence is nevertheless not functional (at least not on the etiological account) and the organ or process has no function, because the evolutionary history is not present. If further generations retain that organ or process as selected for that useful consequence, then it will come to

[5]There are additional issues here involved in what constitutes being an element of a type. Is this tissue mass a kidney, having the function of filtering blood even though it is not doing so, or is it not? I do not focus on this issue here (see Bickhard, 1993, in press-a, in press-b). (Etiological approaches to function encounter the same issue of the metaphysics of kinds, but do not appreciate their complexity.) The central idea is that a functional process can presuppose outcomes and products, accessible in certain manners, of another process and, in so doing, *types* whatever is accessed for those outcomes and products. In other words, they are typed as having the functions that they are presupposed to be serving. The model of representation presented later in this chapter is a special anticipatory version of such process presupposition.

have that consequence as a function. Therefore, the first time (and for however many subsequent generations counts as sufficient), every useful evolutionary innovation is not functional and has no function.

These examples are counterintuitive, but that counterintuitiveness might well be a cost worth paying for the overall power and apparent naturalism of the etiological model. I contend, however, that these examples betray a fatal flaw: the epiphenomenality of etiological function.

Epiphenomenality

The etiological model holds that functionality is constituted in having the right kind of history. No history means no function, even for systems that are molecule-by-molecule identical. However, that is just a way of pointing out that history is not determinable in the current state of the system, and the etiological notion of function is, therefore, not definable in terms of the current state of the system. But only the current state of a system can be causally efficacious, so the etiological model of function commits to the consequence that function has no causal power.[6] Only the current state can have causal power, so etiological function has no causal power: It is causally epiphenomenal.

Because the etiological approach models representation and other normative phenomena in terms of the base-level model of function, not only is function causally epiphenomenal, but so are representation and all of the rest of mind. Etiology commits to an epiphenomenalism of mind (or else some alternative way of accounting for mental phenomena that does not depend on the etiological model of function).

This epiphenomenalist consequence of the etiological approach, in turn, constitutes a failure to naturalize function and mind—a failure with respect to one of the primary original motivations for the approach. I take these consequences to be a refutation of the etiological approach by its own standards—and certainly by the standards of causally efficacious naturalism. Function as a contribution to far-from-equilibrium system self-maintenance satisfies those standards.

REPRESENTATION

I turn now to representation. A self-maintenant system is a far-from-equilibrium system that contributes to the maintenance of its own conditions for

[6]The two lions are, by assumption, causally identical, but one has organs with functions and the other does not.

stability. Such a far-from-equilibrium stability is always relative to the environment in which the far-from-equilibrium conditions must be maintained: The candle flame will not survive a dousing with liquid oxygen because the heat-generating capacity is simply not powerful enough. Therefore, if there are changes in the environment, the self-maintenance of the system may be in jeopardy and a simple self-maintenant system will have no compensatory response possible.

Recursive Self-Maintenance

A *recursively* self-maintenant system, however, is a system that tends to maintain its own property of being self-maintenant against such changes in environment. This requires some contact with the environment that can detect such changes, more than one possible way in which to be self-maintenant, and processes for switching the self-maintenant strategies appropriately to the environmental detections.

Candle flames cannot do this, but one simple example of a far-from-equilibrium system that can is the bacterium that can tumble if it finds itself swimming *down* a sugar gradient, but can continue swimming if it finds itself swimming *up* a sugar gradient (Campbell, 1974b, 1990). Such adaptive adjustments are contributory to self-maintenance insofar as they are undertaken appropriately for the environmental relationships in which the system finds itself. There are two aspects to this recursively self-maintenant property: 1) the detections, and 2) the selection of a next (hopefully) self-maintenant process. Both are of fundamental importance, both to the organism and to the theory of representation. I address the selection, or guidance, of the self-maintenant process first.

Anticipative Selections

The critical property of such selections is that they are anticipative: they are anticipative in the sense that they are future oriented—they are selections of interactions for the immediate or near future and they constitute anticipations that the selected interactive processes will in fact be functional for the system. In other words, they anticipate that the environment will be, at the time of the interaction, appropriate for that kind of interaction to be functional. Such anticipation can be in error: The environment might not cooperate and the interaction may fail to be functional.

There is a very primitive emergence here that is nevertheless of central importance. Such an anticipation about the environment is an implicit predication about that environment—this is an environment of appropriate type for the selected interactive process—and that predication can be false. This is the most primitive version of representational truth value.[7]

Anticipative Indications

These implicit predications are indeed primitive, but additional steps of elaboration and sophistication are both possible and offer increasing adaptive power. The most important are concerned with additional sophistication of interaction selection. The selections illustrated previously are selections via simple triggering: When the appropriate detections occur, trigger the corresponding process. There is no selection process beyond the environmentally induced triggering. In more complex systems, however, environmental detections may indicate more than one possible next interactive process and some further selection of which process to engage in, among those indicated as possible or appropriate, must occur inside the system itself.

If indicated potential interactions are associated with indicated possible internal outcomes, this provides a sophisticated basis for further selection. In particular, the system can make selections on the basis of the indicated outcomes. It can select those interactions whose indicated outcomes best satisfy or heuristically approach current goals; that is, indications of potential interactions and their potential outcomes provide a basis for solving the general problem of action selection.

Simultaneously, such organizations of indications constitute even more sophisticated representations. An indication of potentiality is still an implicit predication and is capable of being false. In this organization, there is also the possibility that the system can itself discover such falsity, should the indicated interaction be undertaken. In particular, if the actual outcome is not among those indicated, then the indications were false. Such error can be useful for further selections of interactions or for invoking and guiding learning processes, should the system be capable of learning. At this point, we not only have representational error, we have system-detectable representational error.[8] Such a claim of the emergence of representation faces a number of possible challenges. I anticipate and address a few of them here.

[7]Note that this claim rejects any simple propositional model of representation, any model that holds propositions to be the only bearers of truth value.

[8]In simple systems, an indication of interactive potentiality will only occur in some particular environmental situation or condition, or with some particular conditional, and will have a corresponding truth value. In more complex systems that are capable of reflective consciousness, organizations of such indications can be separated from any particular conditions or "targets" that they are "about." In such cases, the organization of indications constitutes a representational content lifted out of a normal context of application. A full representation is an application of such a content to a "target," and truth emerges when the content is true of the target and false when the content is false of the "target." Abstracted content, however, can be useful in imagination, counterfactual thought, explorations of content per se, and so on (as well as subject to its own forms of abuse; Bickhard, 1993, in press-b; Bickhard & Terveen, 1995; Cummins, 1996).

Goals

First, if the goals that are involved in interaction selection are themselves representational, then representation has been explicated in terms of representation and the model commits a circularity. This is correct, but the form of goal directedness does not need to have explicitly represented goals. They need only be internal set points for a servomechanism process that selects one space of internal processes if the set point is not met and a different space of internal processes if the set point is met. Once representation is available, then, of course, goals can make use of representation without circularity.

Second, these representations are still quite primitive, perhaps appropriate for worms and maybe frogs, but do not look much like adult human representations of objects or abstractions. Such examples pose a challenge to the adequacy of the representational model: It might provide a model of the emergence of a primitive version of representational truth value, but can it account for more complex and more familiar kinds of representation?

Objects

I address the issue of object representation first. It is already clear that indications can branch out, with more than one possible further interaction indicated at a given time. It is also the case that they can iterate in the sense that the indicated outcomes of one interaction can themselves, if arrived at, serve to indicate still further potential interactions. Thus, indications of interaction potentialities can branch and iterate into potentially vast and complex webs of such potentialities.

A special organization within such webs of interactive potentiality has the following properties. First, all potentialities in the subweb are reachable from all other points in the subweb. In other words, if any part of the organization of potentialities is reachable by the system, perhaps with intermediate interactions with the environment, then all of the subweb is reachable in the same way. The subweb, then, is closed and reachable with respect to the interactions that make it up. Second, that subweb organization is itself invariant under a class of interactions, physical interactions in particular for the current example. I propose such closure, reachability, and invariance properties as characteristic of object representations.

Consider, for example, a toy block. A child can do many things with it, from visual scans to manipulations to chewing to throwing and so on. If any of these are possible, then all are possible, perhaps with intermediate interactions, such as a manipulation to bring a particular visual scan back into view. Furthermore, the entire web of interactive potentialities that the block affords remain invariant under a large class of physical interactions, such as hiding, leaving in the toy box, walking out of the room, and so on, though it is not invariant under such processes as burning or crushing. From an epistemological point of view, this *is* a small manipulable object. Obviously, this is essentially Piaget's model of object representation translated into the language of the interactive model (Piaget, 1954).[9]

Abstractions and Knowing Level Stages

The answer to the challenge of the representation of abstractions is similarly Piagetian. A system interacting with its environment and representing various properties and objects in it may itself, as an interactive system, have properties that would be useful for the system to represent. But the interactive representational relationship is asymmetric, so a system cannot directly represent itself. A higher level system, however, interacting with the first level similarly to the sense in which the first level interacts with the environment, can represent properties of that first level. Properties of the second level, in turn, could be represented by a third level and so on. There emerges a hierarchy of potential levels of representation.

Consider now a property that might be useful for a first-level interactive system. One heuristic strategy may involve doing something more than once in case the first time or two do not work. A control for that could iterate an activity, say, three times. If a second-level system developed a representation of this property of a control organization in the first-level system, that second-level representation would be a representation of the number 3. The second-level system will have abstracted a property of the first-level system.

The relationship here is much like Piaget's reflective abstraction (Piaget, 2001), and, like reflective abstraction, this induces a stage hierarchy of potential development. The reasoning is as follows: Interactive organization cannot be passively induced into a system by the environment. It must be constructed by the system, and tried out to determine if it is useful. Any action-based model of representation and cognition, then, forces a constructivism. If the constructions are not gifted with foresight, they may well be wrong and need to be modified or rejected. Action-based models, then,

[9]Piaget's constructivism is among his most important contributions, showing how an action-based model of representation and cognition could account for the full range of representational phenomena. But Piaget's focus was not most fundamentally on representation per se. He was concerned most centrally with providing a third way that transcended innatism and environmentalism and could account for the emergence of necessity, that classical battleground between empiricism and rationalism (Bickhard, 1992c). His model of representation, therefore, was relatively underdeveloped. It focused mostly on representations of kinds or categories of particulars, such as objects or universals. He did not focus, for example, on the emergence of representational truth value.

force a variation and selection constructivism, an evolutionary epistemology (Campbell, 1974b).[10]

If development occurs via such a constructive process, then it cannot skip over levels of representation in the hierarchy outlined previously. It is not possible for something at level $N+1$ to represent something at level N if that something at level N does not already exist. Therefore, development must climb the hierarchy one level at a time, at least in the sense that there must always be support at lower levels for the particular constructions at higher levels. This imposes a stage organization on possible development, though not necessarily an age-synchronous or domain-general stage constraint. Constructions could be quite variable with respect to which level has been reached among multiple domains of knowledge.[11]

I have argued that the anticipatory aspect of the solution to the problem of action selection is also the solution to the problem of the emergence of representation, and cognition more broadly, with multiple consequences, including a necessary constructivism and a stage constraint on development, thereby providing explanations of such constructivism and stage constraints. I now turn to the detection aspect of action selection.

Detections

In the most primitive model, interactions are simply *triggered* by environmental detections. In more complex versions, environmental detections are the grounds for *indicating* which further interactions might be appropriate in particular environments. Such detections are the means by which an organism is sensitive to the environment in ways that further its own ends

[10]Piaget rejected the power of variation and selection models to account for the exquisite accomplishments of development or even for the exquisite design of the eye (Bickhard, 1992c). In part, he was anticipating contemporary claims that self-organization plays a central role in evolution and development, along with variation and selection (Christensen & Hooker, 1999). In part, he was making an even stronger rejection of emergence, for example, in such claims as that reason evolves rationally or that reason does not change without reason, which, it should be noted, implies that reason can only come from reason: Reason or rationality cannot be the product of contingency (Kitchener, 1986). I reject this Humean claim (Bickhard, 1998, in press-b).

[11]Elsewhere, I have offered a model of the process of ascending such levels, the process of reflective abstraction (Campbell & Bickhard, 1986). It has among its consequences that the ascent to Level 2 should involve a neural maturation and, therefore, should be roughly age synchronous and domain general, whereas all higher levels can be reached in purely logical fashion, with no constraints on age or domain other than the basic sequential constraint outlined previously. This initial age-synchronous, domain-general, developmental shift, followed by nonsynchronous, domain-specific development, seems to be, in fact, what is found empirically (Bickhard, 1992a). Note that there are no structures of the whole in this model, in fact, no structural characterizations of stages at all (Campbell & Bickhard, 1986).

and, in particular, in ways that tend to recursively maintain far-from-equilibrium conditions.

Such environmental detections can themselves be quite complex and can, for example, involve full environmental interactions. For my current purposes, however, their importance is more for their role in standard models of representation than for their dynamics in action selection and anticipatory representational emergence.

The reason is that standard models of representation take such detections to *be* representations, to constitute the emergence of representation. A detection is held to represent what it detects. This view is of ancient provenance, going back to the ancient Greeks, and is still dominant today. In strong contrast, the interactive model advanced here (or any action, pragmatist, model) sees detection as only part of a representation. A repertoire of actions and some way of selecting among them are also needed (Bickhard, 1993, 1999, in press-b; Bickhard & Terveen, 1995). It is worth noting that Piaget was one of the few prominent advocates of an action-based model of representation.

In proposing the interactive model, then, I have issued a promissory note to, among many other things, critique these standard models of representation. This critique is quite extensive, with many related arguments pointing out many related flaws in the approach to representation. Furthermore, additional flaws and arguments are discovered even today. I cannot provide an overview of all of these here, so I focus on a few central and illustrative critiques.

Encodingism

In standard models of representation, internal detections or differentiations of environmental properties (or events or objects) are taken to represent those properties by virtue of some sort of correspondence between the outcome of the detection and the property detected. The crucial sort of correspondence involved is variously claimed to be a causal correspondence, or a lawful correspondence, or an informational correspondence, or an isomorphic correspondence (Bickhard, 1993, 1999, in press-b; Bickhard & Terveen, 1995). The detection is taken to *encode* the property by virtue of that correspondence and representation in general is assumed to have this character of encoding. I have called such assumptions about the nature of representation *encodingism*.

It is clear that encodings do exist, Morse code being a paradigmatic example, so the critical question focuses on the assumption that all representation is constituted as encodings, especially mental representation. Clear cases of encodings, such as Morse code, are cases in which both ends of the encoding correspondence are known and the correspondence itself is known. In Morse code, "···" encodes "s" by virtue of the conventional knowledge of "···" and "s" and the correspondence that links them. Lest this seem to be merely a manifestation of the conventionality of Morse code, consider a usage such as "This neutrino flux encodes information about fusion processes in the sun." Again, vast amounts of knowledge are necessary in order for this to hold: knowledge about neutrino fluxes and how they are detected, knowledge about processes in the sun, and knowledge about the links, the correspondences, between them.

This point is just one perspective on the fact that encodings require interpreters. That is not a problem for genuine encodings, but, if we are attempting to model mental representation, this is unacceptable. Mental representation is (part of) what is involved in some epistemic agents *being* such an interpreter. Therefore, to invoke encodings—any version—as a model of mental representation is to invoke mental representation to account for mental representation, to invoke a regress of interpreters each interpreting the encodings produced by the previous interpretation. Mental representation, whatever it is, cannot require such interpretation on pain of circularity or infinite regress. Here we have the first of a great number of arguments against encodingism.

Piaget (1970) had a powerful version of this circularity and regress argument that focused on the genetic aspects of our representations: If our representations of the world are copies of the world, how do we know the world in the first place in order to be able to construct our copies of it? We would have to already have a copy from which we could construct our copy, which would, in turn, require a still prior copy for the construction of that one, and so on.

Another perspective on the problems of encodingism derives from the recognition that the correspondences of the sort that are supposed to constitute representation—causal, lawful, and so on—are ubiquitous in the universe. Every instance of any causal law, for example, creates a causal, a lawful, and an informational correspondence, while any two instances of any pattern—where what counts as an instance of a pattern is completely free—yields an isomorphism correspondence. Virtually none of these are representations, so the next problem, in the encodingist perspective, is to add conditions to narrow the field to just those correspondences that do constitute representations. If, however, the only kinds of genuine "representations by correspondence" are the genuine encodings, such as Morse code, then this approach to modeling representation is doomed: Mental representations cannot be encodings for the interpreter reasons already mentioned (as well as many additional reasons not mentioned).

The problem is that an element or event that happens to be in correspondence with something else does not announce in its nature either that it is in a correspondence nor what the correspondence might be with.

There is no information available that the element or event in question is supposed to be a representation at all, nor about what the purported representation is supposed to represent. There is no representational content.

Representational content is what specifies what a representation is *supposed* to represent. This is a normative issue: A particular representation is, perhaps, supposed to represent a cow, but is being used at this moment to represent a horse (on a dark night). That is, the representation is false in this instance, and it is the content that determines that this application is in error.

This point highlights still another problem. If a correspondence of the favored type exists, then the representation (supposedly) exists, and it is correct. But, if the favored type of correspondence does not exist, then the representation does not exist and, therefore, it cannot be incorrect. There are three cases that must be distinguished: The representation exists and is correct, the representation exists and is incorrect, and the representation does not exist. But there are only two possibilities available for making those distinctions: The correspondence exists, or the correspondence does not exist. The available resources are inadequate to be able to account for the possibility of representational error.

There has been a major industry in the philosophy of mind in the last two decades of attempts to provide a model of representation that can account for the possibility of representational error. I will not review the arguments here, but none of them work (Bickhard, 1993, 1999, in press-b). At best, they characterize error as some external observer on the system might be able to determine it. For example, an external observer, if it could determine that the representation was supposed to represent cows—that is, if it could determine the representational content—and could have independent access to the world to determine that the case in point was in fact a horse, could then announce that this deployment of the representation was in error. There are two kinds of problems with all of the available proposals: (a) No system is itself in a position to determine the contents of its own purported representations (the proposals can involve complex evolutionary or learning histories, or equally complex relations among various kinds of counterfactual conditions that might have happened, but did not or have not) and (b) even if it could, it would then have to compare the content to what is currently being represented to find out if the deployed content is correctly representing it, but that is the original problem of representation all over again. Circularity rears its head yet again.

The central problem here is that encodingist models provide no model of the emergence of representational content. Genuine encodings borrow their content from whatever defines them, but original mental representations cannot borrow them from anywhere. But there were no representations at the time of the Big Bang and there are now, so representation must have emerged. Any model that cannot account for such emergence is thereby falsified.

Rather than face this problem of emergence, however, major figures in the field develop arguments based on it. Fodor (1981), for example, argued that, because there are no models of learning that can account for the emergence of new content, all possible basic contents that humans are capable of must be innate, must be in the genes (Bickhard, 1991). The problem, however, is a logical one: How can the emergence of content be accounted for at all? If it is, according to some model, impossible, then evolution cannot do it either; conversely, if it is possible for representational content to emerge, then there is no reason available why organic evolution *could* avail itself of such emergence and mental development could *not*. Nevertheless, Fodor's claim has given aid and succor to a major industry in developmental psychology of disproving Piaget by showing that multiple realms of representation must have innate bases.[12]

Just to remind the reader, I point out that the interactive model has no problem whatsoever with the emergence of content in particular kinds of interactive system organization, with the possibility of representational error, or with the possibility of system-detectable representational error. The central problems that have vexed the encodingist approach, for not only decades, but millennia, are trivially solved and dissolved by the interactive approach.

This is just a sampling of the problems faced by encodingist approaches to representation (Bickhard, 1993, 1999, in press-b; Bickhard & Terveen, 1995), but it will suffice for now.[13] It is clear that these approaches suffer from deep flaws, which I argue are fatal flaws. Moreover, it is clear that the most central of them—content, emergence, error, system-detectable error—are trivially solved by the interactive model.

SO WHAT?

A legitimate question at this point, however, is: What difference does it make? How does the interactive model, or any pragmatist model, affect theory in psychology, particularly developmental psychology? The first answer, of course, is that these models of function and representation provide naturalistic accounts of the emergence of two fundamental normative phe-

[12]This is far from the only manifestation of the deep and fatal problems in Fodor's models, but it is one that has had a particularly unfortunate effect on developmental psychology. (For more detailed discussions of Fodor, see Bickhard, 1991, 1993, 1996, 1999, in press-b; Bickhard & Terveen, 1995; Levine & Bickhard, 1999.)

[13]See the references for detailed refutations of particular models, such as those of Cummins, Dretske, Fodor, Millikan, and Newell.

nomena, arguably the only such models. But the second question asks, does the interactive model leave everything else unchanged? Or, conversely, what would be different in this new perspective? There are two kinds of answers to this question: (a) new possibilities it opens up for different kinds of models in cognition and development and (b) changes that it forces in models in related domains. This is not the occasion for any developed response to this question—that would involve a full model of the person—but I briefly adumbrate some illustrative examples from each of these.

Functional Scaffolding and Self-Scaffolding

The first example is an expanded notion of scaffolding that is made possible by the explicit variation and selection model of developmental construction. Scaffolding is usually thought of as involving a Vygotskian notion of internalization (Bruner, 1975), although models of the actual process of internalization are difficult to find (Wertsch, 1985; Wertsch & Stone, 1985).[14] Consider the following as a possible model for what *internalization* is used to refer to, even though the metaphor of internalization works poorly here. If some framework of selection pressures exists external to the organism, then, insofar as the organism comes to be able to satisfy them, it will have constructed, via an evolutionary epistemological process, some means and coordinations of interaction that "fit" those pressures. This is not a straightforward internalization, because what fits or satisfies those pressures may not have any structural resemblance to those pressures at all—it need only be a control system that is interactively competent with respect to them.

In such a view, development will proceed, among other ways, via the construction of task competencies, which will then serve as the foundation for and framework within which further variation and selection constructions take place. It is crucial to notice that any task or selection criterion that requires a great deal of construction to minimally accomplish is not ever likely to be mastered. The chances of hitting on the right construction diminish rapidly as the necessary construction becomes more complex (Si-

[14]The theoretical notion of internalization has drawn increasing attention recently. One theme in this work has been to move internalization from the individual into the social realm (Cox & Lightfoot, 1997; Winegar, 1997). I have strong sympathies with this kind of move as a matter of balance in modeling many of the phenomena for which internalization has been invoked. But no such move can eliminate entirely the fact of changes in the individual and some degree of stability in those changes in the individual; those phenomena must be accounted for. They are the phenomena for which "internalization" has been a most attractive, but unfortunate, metaphor. Thus, the shift of emphasis toward the social cannot eliminate the theoretical problem with internalization and the model presented in this chapter is offered as an account of a part of the individual aspect of the process of what "internalization" might be.

mon, 1969). One way around this difficulty, for tasks that are inherently complex, is to block or bracket some of the relevant selection pressures. In this way, some easier constructions that are much more likely to be found may become successful in the reduced selection pressure environment. If such blocking of selection pressures is ultimately successful, it may become possible for the organism, the infant or toddler (or adult), to ascend a path of such "special environment" points of constructive stability to eventually reach a full task competence with respect to the full task selection pressures. At that point, of course, there is no longer any need for the blocking of selection pressures: The construction of the full task competence has been "scaffolded" by those blockages, and the scaffolding can be dismissed when the full construction is accomplished.

This functional notion of scaffolding provides a more general way of thinking about scaffolding and its possible functions and uses, but it also has a special consequence: Self-scaffolding becomes a possibility. If to scaffold is to provide a structure or organization that can then be internalized, then self-scaffolding makes no sense. If, however, to scaffold is to block selection pressures, then it is clear not only that an individual can do it for him- or herself, but also that we all do it all of the time. We break problems down into subproblems, we move to ideal cases, we seek resources that we can perhaps do without later on, and so on. Once the point is seen, in fact, it is clear that self-scaffolding skills are a major aspect of development, one almost universally overlooked.[15] Elsewhere, I offer a model of attachment as a form of self-scaffolding (Bickhard, 1992d).

Another possibility opened up by this functional notion of scaffolding is that of permanent scaffolds, scaffolds that are necessary to particular kinds of interactions and accomplishments and that are never discarded. I argue that the emergences of social reality, culture, and language have this character of permanent scaffolds (Bickhard, 1992b).

Cognitive Dynamics

A second example of a new theoretical possibility in thinking about cognition has to do with the dynamics of cognition. In standard models of representation, as previously mentioned, there is no model of the emergence of representational content. Because content cannot emerge, according to such models, it must always come from somewhere: It cannot just "emerge" into existence. With a focus on the organism, there are only two possible

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[15]Self-scaffolding is likely to be an important aspect of what might often be simply categorized as scaffolding. If so, then scaffolding will (most) often be a coconstructive process, with a simultaneously active individual and active environment, with respect to the construction or utilization of blocks to selection pressures.

sources that it could come from: the environment (empiricism) and the mind or genes (rationalism). These are the alternatives that Piaget wanted to transcend with his "third way", and his efforts were quite well directed: They can be transcended by a model of emergent content, content that does not have to come from anywhere.

This assumption that content must always already be there (somewhere) is behind the Fodor argument mentioned earlier that all content must be innate and the flaw in that argument is apparent once it is recognized that content *has* to have emerged at some point. It is also deeply embedded in the computer-inspired models that so dominate the current scene. Symbol types are categories of symbols for which content is already known. Some hope that connectionist models will solve this problem or contend that they already do solve this problem, but trained connectionist nets provide *correspondences* between activation vectors and categories of inputs—they do not provide any content for the net itself about the fact that any such correspondence exists or what any such correspondence might be with. In other words, connectionist models do not address the problems of content; they only provide trainable correspondences. That is not trivial, but it is not representation either (Bickhard & Terveen, 1995).

Within the confines of such conceptual frameworks, cognition is thought of as the processing of such symbols or the flow and interactions among activation vectors, with content always presupposed to be in the background, somehow flowing along in parallel with the symbols or vectors and somehow making all these things into representations. If, however, content, thus representation, is freely emergent in certain kinds of system dynamics, then a very different kind of view opens up.

In particular, the creation of representation does not have to proceed via intermediary representation. Cognition does not have to "operate on" already-existing representation. Representation can be created and eliminated over and over again in a broader dynamic process. Representation can occur as a kind of organized froth on underlying cognitive dynamics, something like the froth of virtual particles in quantum field theory, at times simply disappearing and at other times having a major impact on the ensuing dynamics, again something like the emergence of conserved "particles" out of the froth of virtual particles in quantum field theory.

Such a view of cognitive dynamics makes very good sense of many results in cognitive psychology that are anomalous in standard views. These include evidence that categorizations are created anew for each new occasion and are in some ways unique for those occasions, that categorizations and judgments of similarity are highly context dependent and highly history dependent, that the constructive similarities of metaphor are central to cognition, not a secondary add-on, and so on (Bickhard, 2000a; Bickhard & Campbell, 1996; Dietrich & Markman, 2000; Freyd, 1987; Shanon, 1993;

Smith & Samuelson, 1997). These kinds of dynamics are handled either not at all or, at best, with very ad hoc additions, in standard models. A model of the dynamics of representational emergence, then, provides a very different view of the nature of cognition in general.

Related Domains

A pragmatic approach to representation not only opens new perspectives on its home ground, but also forces multiple changes in related domains. I do not provide an overview of any of these changes here—that is a vast programmatic project. I do, however, show how the pragmatic, interactive model and its associated critiques force several standard ways of thinking to be given up and opens up new avenues for exploration.

For one major example, if representation cannot fundamentally be a matter of encodings, then perception cannot be a matter of the transductive generation of encodings. A pragmatic, dynamic, interactive model of the nature of perception is required. I have argued that Gibson provides the core of such a model, though much overstatement must be peeled away and several important lacunae must be filled (Bickhard & Richie, 1983).

Equally, if representation cannot be a matter of encoding, then utterances cannot be the (transmissions of) encodlngs of mental contents. I have argued that social and functional models of language are steps in the right pragmatic direction, though here too there are deep vestiges of encodingist assumptions that are difficult to discern and difficult to remove. Language as a tool for interacting with social realities, not as a transmission of mental contents, is the kind of model ultimately arrived at (Bickhard, 1980, 1992b; Bickhard & Campbell, 1992; Bickhard & Terveen, 1995).

Finally, if persons are processing units operating on encoded information in their memory banks, then human sociality is nothing more than a storage of social information in those memory banks. Sociality is not constitutive of the person per se, but only of the information and skills available to that person. That is, human sociality is not a genuine emergent of development.

If, on the other hand, human beings are constituted in their interactive processing dynamics—if that is the basic ontology of persons—then the development of a social being in a particular family and culture is the emergence of a particular instance of a particular kind of being, formed in the context of and using the resources available in the social and cultural environment. It is only a pragmatic perspective on representation and persons more broadly that can account for the emergence of persons as social beings with a genuine social ontology, not just processors with a batch of social knowledge to be processed and used (Bickhard, 1995, in press-c).

CONCLUSIONS

Emergence, particularly normative emergence—particularly representational emergence—is at the heart of contemporary naturalism, and at the heart of contemporary psychology. It is the central issue in psychology becoming integrated into the naturalism of the sciences, of finally escaping the heritage of Cartesian dualism.[16] Issues of emergence come into sharp focus in developmental psychology: If psychological phenomena emerge somewhere other than in evolution, they do so in development. Piaget is among the few psychologists to address representational emergence and to do so within a framework that does not a priori preclude such emergence: pragmatism.

I have outlined a pragmatic, a dynamic, model of the emergence of normative function and of representation. These models carry forward the general programme of naturalism, without falling prey to the trap of eliminative reductionism, and provide a foundation for studies of the mind and person more generally. They do not, however, leave the remainder of the landscape unchanged. Illustrative new theoretical openings and forced changes are outlined with regard to scaffolding and self-scaffolding, cognitive dynamics, perception, language, and human sociality. Pragmatism provides a powerful alternative approach to understanding persons, but one that requires deep and sometimes difficult changes.

AUTHOR NOTE

Mark H. Bickhard, Department of Psychology, 17 Memorial Drive East, Lehigh University, Bethlehem, PA 18015; e-mail: *mhb0@lehigh.edu*; web site: *http://www.lehigh.edu/~mhb0/mhb0.html*.

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[16]It is frequently assumed that there is a dichotomy between dualism and reductionism, such that arguments against (Cartesian) dualism are taken to be arguments for reductionism. This is false and based on a false dichotomy; emergence is the third way that transcends both possibilities.

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