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The Openness of Structure

Our goal is to develop a model of mind that will permit the development of a science of consciousness that integrates biology, psychology, intentionality analysis and sociology. As a single model, it both abstracts from and integrates other models. To understand both the model we are developing and the models it integrates it will be useful to concentrate on development which itself can be comprehended only through multiple models. Development, in turn, can be understood abstractly or concretely. As abstract, understanding either approaches or attains the general case. As concrete, it explains the particular in terms of the general through additional insights into particular data. As concrete the explanations can be as various as the multiple forms of life and the individuals within species that are the objects of a theory of evolution.

For simplicity, we will confine our account of development to that of living things. We will first look at development as structured. This will allow us to get an initial grasp of the sequential regularity of the emergence of greater complexity and differentiation. By understanding the most general case of emergence, we will introduce some instability into our simple model and begin to understand how development can exploit the nonsystematic. This will provide us with a more complex model. Finally, by understanding that organisms exist in situations, we can understand why development ***must*** exploit the nonsystematic if species are to survive. This will permit us to understand the importance of the phenotype for evolutionary change. It also will allow us to understand why variation at the genotype level is required for successful development. (similar to the behavior issue – need to adapt to varying situations – which is why we can have the dog we have.)It also will permit us to understand the role of the group in human development utilizing our previous discussion on the development of language. Finally, we will be able to understand the role of historical explanations in natural science and the limits and validity of teleological explanations.

Lonergan defines a thing as a unity, identity, whole. He notes that we have a notion of a thing, meaning that we do not have a fully differentiated and integrated conception of it. We understand the unity of a thing via insight, but the unity that is grasped ranges from a relatively cognitively undifferentiated "oneness" to unified structures such as that of a functioning plant. It is the grasp of a unity in data where all the data pertains to the thing. Yet for this understanding to transcend the immediate situation, we know from the work of Piaget, that the understanding of the conservation of objects takes months for the infant to achieve. Thus, grasping that the same thing is manifest in different instances over time requires additional insights. The thing is also a whole. To understand it as a whole we face greater challenges because we need to enter an explanatory framework. The understanding of it as a whole can be implicit, as it could be in the botanist's understanding of a plant. Or it can be explicit as in the philosopher's understanding of a whole as such. It is to the latter realm that we will turn to understand the thing as a whole. We will do so beginning with the following problematic issue.

There are no things within things. But are there wholes within wholes? If we strictly interpret Lonergan we could make a case that he thinks so, since cognition is a structure, and as a set of operations performed by persons, who are things, we would seem to have a structure within a structure or a whole within a whole. On the other hand, he notes that the notion of the thing is ambiguous. As we shall see, so is the notion of structure and the corresponding notion of whole. That ambiguity arises in his notion of development where a prior integration brings forth the conditions for the subsequent integration, which in turn comes into being via the law of effect. By understanding this we will see that the thing as a whole embodies the nonsystematic. It is a whole, but it is not a fully integrated system. This lack of total integration constitutes the openness of structure. It is the nonsystematic which provides the flexibility we experience in our self-transcendence. It is a basic property of living things to be related to what is not them. At a basic level it is food. At the level of intentionality it is being. Any discussion of structure that does not incorporate the other is abstract and incomplete. It is the relatedness to the other which is the openness of structure. It is that openness which drives evolution, development and performance.

Perhaps the easiest way to understand this is to start with a comparison of Structuralism's and Lonergan's notion of wholes as structures. We will in turn introduce the notion of stochastic explanations, introducing the nonsystematic into structures. Then we will point to some scientific examples to illustrate these ideas. Finally, we will apply them to development and emergence. This will enable us to provide some definitions for explaining consciousness and behavior which are trans-disciplinary but obey the scientific canon of parsimony.

Structuralism views structures either synchronically or diachronically. The synchronic view lays out the structure at a particular time while the diachronic explores the changes over time. At its most general, the synchronic would lay out what the structure is like at any particular time. At is most particular, it would explain its current state.(check on this in Saussure)

> First, the structure exhibits the characteristics of a system. It is made up of several elements, none of which can undergo a change without effecting changes in all the other elements.
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> Second, for any given model there should be a possibility of ordering a series of transformations resulting in a group of models of the same type.
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> Third, the above properties make it possible to predict how the model will react if one or more to its elements are submitted to certain modifications. (Levi-Strauss – Structural Anthropology p. 279)

If we consider structural transformations as systematic, then we could conceive of development as fully systematic where a prior state causes the next via a set of operations. These operations may be supplanted by the next stage, but the link between them and the subsequent stage is fixed. (what does Piaget call operations in the pre-operational stage?) Development in this sense approaches a cybernetic model.

I am not claiming that all Structuralists consider all or any structures to be fully systematic. Rather I am using their notions to develop the concept of a fully systematic structure. At the other extreme are the post-Structuralists, such as Derrida. Via his notion of the meaning of a trace as embedded in an nonsystematic collection of other traces distinguished via their differences, he deconstructs texts and arguments. Rather than meaning being fixed, it is transitory as the values of signifiers change with increased understanding, cultural transformations and so on. Thus, the book as structure decomposes into an indeterminate set of linkages to other possible meanings for each of its elements. The theory of Structure itself becomes a mirage which also has coincidental and irreconcilable meanings. To illustrate his thesis Derrida evokes traces with irreconcilable meanings where significance is perpetually in play, where the *differences* among traces conditions *differance*, or the permanent deferring of meaning. Now, this is not pure chaos, because there are sets of meanings, but the sets are not linked. Thus, structure has been replaced by the nonsystematic.

In the Hegelian spirit we will reconcile these views by following Lonergan's tack of taking the best from both traditions.

The Notion of a Whole

Lonergan distinguishes a whole as a collection from a functional whole. As a collection it can be an aggregate that is arbitrary or conventional. A quart of milk is conventional since as a measure one can consider it as divided into parts arbitrarily. The milk itself is a mixture. As such it is a collection or aggregate of different types of entities. A functional whole, however, approaches Levi-Strauss' definition of structure. He notes that the whole as structure is illustrated in "…highly organized products of art and nature where every part is related to the others. Every part is just what it is because of its relations to the other parts." How are we to conceive these relations? (p. 216 Phil and theo papers 1958-1964). In this essay they appear to be fully systematic.

In his explication of the notion of mutual mediation, the door is opened a bit to understanding them in a more open-ended fashion. He distinguishes the immediate and the mediate. The effect is immediately related to its cause as, in a sense, being produced by it. The effect can then be utilized in another process. That utilization is a mediation of the effect. We can think of organic systems, then, as mutually mediating. One part of the body can produce biochemicals used by another part and vice versa. Now, if we consider the body, or any complex organism, as a set of active centers, then those centers can produce effects that are utilized in some manner by the other centers. Via mutual mediation a complex network of interrelationships among centers can be established. The question arises, are all of these interrelationships themselves interrelated. Is this complex a fully integrated system?

In the case of development it appears that it is not. As a succession of levels of integration the form of the organism at any one time is a higher integration of parts, which themselves can be integrations. In the discussion of development in Insight, this higher integration is characterized as a higher system which fulfills the two major roles of being the operator of development and the integrator at each developmental stage. Development is from lower to higher integrations. But it would appear that development for Lonergan is not fully systematic. First, the operator is an upwardly directed, but indeterminate, dynamism. Second, the operator as bringing forth the conditions for the higher integration "…provokes the underlying instability." (p. 490, Insight) The higher integration occurs not deterministically, but via the law of effect. “The law of effect states that the ground of functioning advances to a new ground of functioning where functioning occurs successfully.” The higher integration is conditioned and is itself a de facto accomplishment. This indicates, at least implicitly, that it could be different. If the operator of development in moving from one stage to another is understood as assembling conditions and if these conditions come from parallel, unintegrated processes, then the operator is diffuse and non-systematic.

However, if one turns to his notion of the nonsystematic and applies it to systems, as we will do now, we can understand the openness of structures and development and how it conditions their success.

Structures are both systematic and nonsystematic. They can be systematic in their operations but nonsystematic in their states. (Enablement) They also can be nonsystematic in their operations and systematic in their states. (emergence). Finally, they can be nonsystematic in both or systematic in both. The former could describe an animal in a learning situation; the latter a simple computer. Let’s get an initial take on this by considering Lonergan’s notion of cognitional structure in relation to the account of world process and emergent probability provided in the first half of Insight. This will provide as with a notion of dynamic structures as wholes which display both characteristics. We will move then to understand how this works in general in development, with an necessary detour to understand the emergence of structure. We then will introduce some terminology to let us handle the next piece, understanding the openness of structure via its relation to the other.

Holism and Evolutionary Differentiation

The evolution of development was the evolution of constraints that permitted independent internal processes to yield results that led to the emergence of higher structures or integrations. The internal environment became richer. There always was an issue with adaptation to variation within the internal environment. But for a species to survive, it became advantageous for a gene pool to evolve where development could accommodate greater variation resulting in variation in structure within the species, so that the species could yield behavior that would survive the vicissitudes of significant environmental change . This evolutionary gradient yields a development within the constraints set by the gene pool and its resulting range of structures at each level of development analogous to the accommodation of the organism to the external environment. Is this surprising? Conceptually it is not, if we consider the organism not in isolation, but as a thing whose behavior is what it is because elements that are not it are integrated within its functioning. That is, for the most part, it does not behave or perform without incorporating what is not it within the behavioral schemes of recurrence. So the basic performance of the organism within its habitat is exploited in the emergence of development.

The evolutionary "strategy" was for systems, which support key activities to become differentiated from one another. This differentiation was possible due to the emergence of greater complexity. For example, the reproductive, metabolic and motor functions became differentiated within the cell. The development of a nucleus in the cell provided a more complex and more specialized structure. As the cell membrane provided boundary conditions within which the cell could perform its functions, the nucleic membrane provides the same function within the cell. Not only does this secure advantages in the life cycle, it also provides a greater flexibility for evolutionary innovation since evolutionary changes can occur independently of one another within the systems within ranges that can be assimilated by or accommodated to by the other systems. A similar process occurred with groups of cells. The unity of cells as one organism evolves into partially independent systems of cells that perform key functions. These systems may be or have operational or organizational centers that have some autonomy with respect to other systems. The organization is modular where many of the processes within the modules are separated by boundaries from processes in other modules but where rich interactions can occur via biochemical processes. As these systems became more autonomous from one another, they became subject to higher regulation, as systems evolved to coordinate the activities of the systems. The same process has been reiterated with respect to those systems. A case in point is the evolution of the motor system. As muscular groups became increasingly differentiated from one another, they also became more coordinated through the evolution of the nervous system. The nervous system itself was subject to the same general evolutionary principle as neural centers evolved to support the various senses and movement. It appears that differentiation and new coordinations are linked.

A key point is that the unity of the organism is maintained. This is illustrated by the fact that in animals, no self organizing processes survive death and those that do (i.e. the growth of finger nails) soon stop. This means there is no fully independent process in the organism. Everything is interdependent. If non-related processes emerge there are complex processes that occur to eliminate them, such as the triggering of cell death and the processes of the immune system. Diseases such as cancer and viral infection survive and reproduce by mimicking the organism's protein or by affecting the processes that would destroy alien protein. However, neither survives as actual process without the living organism.

The holistic interdependence of the organism suggests that the notion of hierarchical structure is misleading. Rather than the image of the organism or systems being structured like a pyramid with the central operator being at the top, a more apt image is an inverted pyramid which represents the development of the organism with the top of the pyramid representing the latest configuration. The latest configuration is the organism as a whole with a potentially integrable set of operations. Any distinction of levels is abstract, partitive, and potentially misleading.

Complex Systems as Stochastic

The correlate to classical laws in understanding organizations is the system. The notion of system is subject to similar limitations in understanding the concrete situation. The situation is nonsystematic. Since living systems are open, meaning that elements of the environment are components within their systematic cycles, they need to be adaptable in the situation in two major ways. First, if there are multiple cycles where the environmental elements are available nonsystematically, then the cycles need to occur as the elements are present. If multiple elements for multiple cycles are available, then some selection criteria, or means of selection, are needed for cycles to emerge without conflict. This requires internal regulation of cycles. Second, if there are environmental elements which can disrupt the cycles and put the organism at risk, then there need to be processes or structures aimed at excluding or destroying these elements or repairing any damage they have done. Within a complex system the same types of threats and opportunities can be present as a result of the system's own activity. This variability permits evolutionary change beyond mutations of DNA.

Since development is the emergence of new cycles, schemes of recurrence or performances, the same situation occurs at each point. This means that each point in development is a possible occasion for variation depending on the situation, which is multiply and complexly conditioned. (Emergence of Complex Systems, pg. 54-5) It is multiply conditioned since there is more than one condition. It is complexly conditioned since the conditions result from the processes of other elements and since their occurrence may be coordinated or "timed".

Considering that systems can be in states other than their current one, it is not paradoxical that systems rely on a lack of system for their functioning. Their potentiality for reintegration could rest on having some unintegrated elements at any one time. However, it is also possible to conceive of a system with multiple states with no unintegrated elements at any time. So lets discuss some of the virtues of the nonsystematic aspects of complex systems and some areas where they can be exploited in biological systems.

The simplest case is a set of similar elements where the existence of the set permits operations, or has qualities, which the individual elements do not have. Consider a set of muscle cells constituting a muscle fiber. The strength of the muscle fiber is related to the muscle cells, but the relation is not reductive. Up to a certain point, the loss of individual cells will not affect the strength of the fiber. Likewise, a threshold is reached where more cells may interfere with effective action of the fiber. Thus, there is a range, which constitutes the effective number of muscle cells within a fiber. Dealing with the individual cell itself as individual, it either is there or it is not. Thus, the notion of range does not apply to it as an individual, though it may apply to processes within it. The fiber itself has a range of extension or flexion, which is effective. Beyond that range it suffers atrophy or tears.

The functional independence of the group from the individual permits a turnover, or renewal, of individuals within the group without loss of function. It also permits greater flexibility in controlling the operation of the group, since the activation of the individuals can occur within ranges and since all individuals within the group do not need to be activated for all operations of the group.

Individuals within a group can be related to individuals within another group permitting situations in one group to cause a corresponding situation in a different kind of group. In other words, a population can create or contribute to a situation, which is related to other situations in other populations. A population of cells creating hormones in a gland for use by other populations of cells in other parts of the body is an example. Again, it is not the individual, per se, that is important, but the number of individuals and their collective state. That collective state does not need to be a higher level of organization but can be understood statistically.

Stochastic relations can be qualities that the group can have that the individual does not have. The relations are not isomorphic to relations obtaining in the individual since, clearly, the individual is not composed of a population of itself. It is simply one element, or variable, within the group. Thus, stochastic relations cannot be understood reductively, or in terms of the individuals and their immediate relations. This type of structure corresponds to the mass action of aggregates noted in the last section.

Stochastic relations provide some means of understanding the linking of situations to one another, even if they are of different elements. If we consider stochastic relations obtaining among the parts of an individual, then we have some understanding of the qualities or properties of the individual in terms of them. This provides some explanation of how unpredictable qualities can arise within things, providing a type of emergence complementary to that of higher levels of organization. It also provides some explanation of dysfunction, since the level of production of biochemicals, for example, may not be sufficient to support the activities of the threshold number of another population. Consider the production and the levels of neural transmitters in the brain and their relation to mental illness.

The stochastic relations among situations provides some understanding of the visual system. In the retina are an aggregate of rods and cones, which are specialized to some extent to respond to different facets of the visual field, such as direction of movement and intensity and wave length of light. The aggregate of neurons in the optic nerves radiates onto other visual processing centers. These other centers are more complex than the initial processing center. They deal with feature recognition and other higher integrations of visual input. They in turn are related to other neural centers for other types of operations. The state of the population of neurons emanating from the eye conditions, but does not determine, the state of the neurons in the other centers. In fact, their state is conditioned by the inputs. Thus, though the inputs are single, as a population they may constitute a pattern, which is matched by the patterned response of the rods and cones.

The lack of an overall organization permits the system to be open enough to handle a range of visual experience. Also, it is the lack of an overall organization between centers that permits a range of combinations of operations. The existence of stochastic relations, then, makes a system more open, more flexible, and more unpredictable.

In the visual field, for example, the positions of structures in relation to the eye are not static. We see them from different angles, in different light and so on. This means that different rods and cones are involved in seeing it at different times. Different sets of neurons are involved as the image is constituted, yet the same image is presented for consciousness. The neural function can be understood as a dynamic pattern of operations, which can be actualized across a network of neurons. Though the network may map fairly tightly to the sensory sources, since the sources themselves are equipotential with respect to providing elements for structures, or gestalts, the network must be able to handle this variability. The neural network makes patterns possible, but it’s action is not sufficient to explain why the particular patterns are as they are.

We have concentrated on events or relations between events, and their statistics. Tthe timing of events and the relations of these to one another can also be systematic or nonsystematic. As nonsystematic the organism’s organization in terms of them may require the development of the proper timing and sequencing.

Returning to the matrical notion of the brain, we can understand how neural structure enables performance. Corresponding to the neural network is the matrix of operations, which it supports. Consider first that neural networks, or centers, or areas perform different operations. Second, they have pathways that intersect permitting the coordination of these operations. Third, the operations can be combined in various ways yielding a myriad of possible combinations. Since the same operation can be combined with numerous other operations, there is a matrix of possibilities constituting the flexibility of the system. This provides us with an initial understanding of the possibility of actualization and of the body as enabler of performance.

The advantage of a matrical structure is that different organizations can emerge. It has an openness and adaptability that a stable hierarchical structure does not. With a matrical structure a variety of hierarchical organizations can be supported without the addition of more elements. In the brain these different combinations seem to be supported by the growth of new synapses conditioning more adaptability and refinement of function.

Thus far we have understood how structures can be non-systematic. At this point we can understand how life is intrinsically, though de facto, nonsystematic. This requires expanding the notion of schemes of recurrence from sequences of events to states.

Attempts to understand the emergence of life have floundered on two issues. The first is the attempt to understand its complexity systematically and the second is to understand reproduction as requiring a DNA like template. Since life is reproductive, somehow an extremely high level of complexity needed to emerge. The gap between life as systematic and the nonsystematic convergence of its conditions is huge. The notion of schemes of recurrence, or cyclic processes, provides some insight into emergence. If a scheme is possible where A causes B which causes C which causes D which causes A, then all that needs to happen is for any of these events to occur to initiate the scheme. Now, the scheme does not cause itself in the sense that it generates its own conditions, but it is part of the cause in that it becomes itself. Thus, emergence has two causes, the conditions for the initiation of the self-sustaining process and the process itself in its becoming. In this sense, emergence can be fully explanatory though there is a logical gap between the assembly of the conditions, the conditions as unorganized, and the resultant scheme as organized.

The emergence of life is not simply the emergence of schemes, but is the emergence of a whole. The most basic question is what kind of structure does the whole need to have to be self-sustaining whole. As self sustaining, life does, in a sense, reproduce itself within itself. As reproductive it produces another. A clue is found in Kauffman's hypothesis for which he has mathematical support:

> We reach a new and fundamental conclusion: for any fixed probability of catalysis P, *autocatalytic sets must become possible at some fixed complexity* level of numbers of kinds of polymers. The achievement of the catalytic closure required for self-reproduction is an *emergent collective property in any sufficiently complex set of catalytic polymers.* (Kauffman, The Origins of Order, p.310)

These would be structures of interrelated bio-chemical processes which recurrently replicate states of polymers sufficient to maintain existence as a whole. In this case we need to shift from a consideration of schemes of recurrence where the schemes are linked sets of events to the recurrences of states. The notion of a whole as having recurrent states is compatible with a unity of independent processes yielding results in the context of a schedule of probabilities. It is this notion which underlies Kauffman's hypothesis of the origin of life consisting not in the emergence of a self-replicating entity embodying some type of DNA or RNA like template, but of a bounded set of biochemical processes open to the environment that maintain a threshold of cycles of reactions that maintain existence within a range of states. There is enough order to maintain existence and enough disorder to permit adaptation to the environment and subsequent internal specialization into metabolism, reproduction and development.

From these principles we can move very quickly to a set of criticisms and conclusions. First the notion of a matrix of relationships provides an instance of a combinatorial model that would be understood statistically. The matrix becomes more robust explanatorily if we understand it as a set of events, operations, or elements in general which are not fully related. Kauffman has called for a new statistical mechanics to understand the complexity of biological processes.

Second, we can understand stages of development as the emergence of different matrices of relations where the emergence of a higher integration is akin to an instance of adaptation to a complex situation. The integration is not fixed, but flexible. The notion of moving to a different stage is not that of moving to a more systematic functioning, but to moving to different principles of operation as structuring performance, where performance is understood in these cases simply as the highest level of operation. This contrasts with the notion of performance of an organism in an environment where the performance incorporates elements which are not the organism. In development parts of the organism can be involved versus the whole organism. In performance, the whole organism is committed via its actions.

Third, the need for flexibility selects against fully systematic organisms. Rather the role of systems is subsidiary. They function best in controlled environments with a fixed set of elements that the system processes so it can deal with every situation. Thus, we find systems within the body, but development and performance are the non-systematic integration of systematic processes. Rather than organisms evolving to be more systematic, they evolve to become more flexible. Because life relies on what is not itself for its survival and reproduction, living systems are open. Because the external situation can change, affecting the availability of what organisms rely on, they must be adaptable. They must be able to replace an element with another within current processes – like assimilation – or change the process – accommodation. If they do not, they die and the organisms which can adapt survive. This is basic natural selection. But it would seem then that evolution itself selects for the more adaptable organisms, or those which have more flexibility in situations. Since the non-systematic is more flexible than the systematic, the non-systematic is intrinsic to life.

Fourth, the limitations of Boolean or cybernetic models including computational models are apparent. Boolean models rely on binary alternatives. While it has been shown that they give rise to complex structures, organic structures rely on physical-chemical processes in their inception and an array of evolved operations in their performance. The actual organism is exponentially more complex. Similar reasoning applies to the computational model which essentially comprises parallel processing Boolean networks. Parallel processing occurs in organisms but it is comprised of a matrix of different kinds of processes versus an array of similar processes. The model for understanding is not matrix algebra, but akin to the call for a more robust statistical mechanics.

We have focused on life as an open whole and its emergence and development. In development the conditions are constrained. It is the lack of constraint over environmental conditions that contributed to evolution. However, just as life constrains the conditions for development, there are similar strategies employed in transforming the external situation. There also is the transformation of the environment to enhance their habitat. Organically we see this in the creation of top soil by plants. In animals we see it in the emergence of social behavior that supports or yields learning, the existence of complementary behaviors within the group in hunting, raising the young and so on. The interaction within the group is part of the situation within which animals, or persons, find themselves and elements of it are necessary for individual development. Society in the broadest sense evolved to enabling individual development. It provides external constraints to and external conditions for conscious development or performance. The quintessential example for humans is learning language.

All of these elements come together in the learning of language. This is an example of the general strategy of embodying learning via critical periods. The general structure is that a motivational window opens that is biologically supported to develop a set of skills, be it recognizing visual patterns, walking or speaking. In the case of speech there are a series of linked emergences of verbal skills. The first is the universal stage of babbling. Here we see the evolved strategy of supporting a broader array of operations than will be selected to support a wide variety of situations in which the infant may find themselves. Thus, humans can learn any language in any culture that they grow up in. The babbling phase terminates with the selection of the range of speech sounds required to hear and speak the communities language. Ability to hear some of the sounds supported earlier goes away with the counter intuitive result that native speakers sound different to native hearers than they do to non-native hearers because they hear differently. Moreover, this transformation provides the imaginal conditions for understanding language since experiencing is attuned to the sounds that constitute the spoken word. Not only do we see the principles of over-differentiation and flexibility at play, but also the constitution of the environment to support development. This is evident in the need for complementary babbling partners. These are not peers, but teachers. Adults and other mature language users babble and engage in other word play with the infant and these interchanges are instrumental in the development of the particular language for the child. Thus, the child's development and consequent biological transformations are conditioned by and dependent on the society with which they interact. These facts themselves are not surprising. But what I hope has proved helpful here is the provision of a model of structure which helps explain them.