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COMPLEXITY AND ERROR IN SOCIAL DYNAMICS

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Let us recall the basic features of the model of cultural dynamics which we proposed in connection with Colin Renfrew's work on the Evolution of Cultures. In that analysis, Renfrew identified five classes of essential activities valid for any culture. These are: 1) Subsistence-related activities 2) Techno1ogy-related activities 3) Social or behavioral activities 4) Symbolic or projective activities 5) External-related activities. Each of these classes is itself composed of many individual kinds of activity. Every member of a culture will spend some fixed fraction of a convenient unit of time engaged in one or another activity belonging to these classes. Thus, one way of describing the state of a culture is by specifying a spectrum of such activities for the individuals of the culture. We showed earlier how we could begin to develop a taxonomy of cultures in these terms, as well as an idea of the "distance" or separation between cultures. This static description of a culture must be supplemented by a dynamical idea specifying how cultural states change in time. This can be done by specifying, for each kind of activity, the degree to which that particular activity excites or inhibits the rates at which every other activity in the culture is pursued. The resulting pattern of excitation and inhibition between cultural activities is as much a part of the overall description of the culture as are the activities themselves; knowing the pattern of excitation and inhibition, a given initial state of the culture will allow us to predict the evolutionary pattern of the culture over time, at least in a fixed environment.

In a subsequent paper, we considered how such ideas could be related to the concept of cultural survival. In this process, we came automatically to a notion of conflict as a consequence of the structure of any differentiated society. Briefly, the reasoning ran as follows: the fact of differentiation means precisely that different individuals in the culture spend their times in a different spectrum of activities, As a result, their own internal models of what the culture is like will be different. So too will be the features of the culture which these individuals regard as essential for the survival of the culture and their strategies for ensuring survival. We have argued that many modes of conflict arise in precisely this way and that a possible strategy for conflict resolution involves imbedding individual partial models of a complex social organization into a more comprehensive model. It is one of the tasks of system theory to articulate the conditions under which this can be done. We will discuss some ramifications of this question in the present paper.

In all of the above discussions, there has been no overt discussion of error and its role in cultural evolution. Yet, intuitively, we feel that error must play a role in cultural processes analogous to that played by error in biological evolution. At first sight, it appears that there is no room for the concept of error in the deterministic social dynamics we have sketched above. We shall show however, that this is not the case; the concept of error arises as naturally in the social context as it does in biological ones, and moreover, an appreciation of this will allow us to draw yet another kind of parallel between biological processes and social ones.

It will be well to begin with a general discussion of error in complex systems. We shall argue that what we interpret as error is really an inevitable correlate of complexity itself and this, in fact, is what provides the richness for evolutionary processes. Indeed, the concept of error becomes meaningless outside the context of complex systems.

For our purposes, we will call a system *complex* if we can interact with it in many diverse ways, each requiring a different mode of system description. Conversely, a system is called *simple* if we can interact with it in only a few ways, or in ways which require only a single mode of system description. Thus in particular, complexity is not an intrinsic property of a system but is rather a property of our capacity to interact with it

Any particular *mode* of complex activity, however, can be regarded as if it were a simple system. This is a corollary of the basic assertion we proposed earlier, namely that in carrying out any single functional activity, a complex system uses primarily only a small number of its available degrees of freedom (i.e. of its capacity to interact with other systems). Indeed, this fact is basic to all of the abstractions which make scientific analysis possible; we simply abstract out all of the apparently in essential properties of the system leaving behind basically one simple system, with one specific interactive capability.

In this context, we will argue that systems simple in this sense cannot make errors. Such systems are governed by behavioral laws which cannot be violated within the framework of the simple system itself. It is meaningless, for example, to speak of a system of mechanical particles, such as the solar system, making an error. In biological modeling, error must be introduced by some extraneous means, such as a probability distribution superimposed in an *ad hoc* way on the inviolable behavioral laws which govern the model. (This distribution then plays the role of all the other degrees of freedom of the real system which we have abstracted out.)

In any real complex system, however, as apart from any particular model of one or another of its activities, many functional processes (interactions) are being carried out simultaneously. Each of these functional properties utilizes only a small fraction of the available degrees of freedom of the system, and so can be abstractly separated into non-interacting models. But in the real system, each of these activities must have some effect on all of the others. If we were to look at any one activity in isolation, and suppose it to be governed by the inviolable behavioral laws it would obey if it were a simple system, we will observe a deviation between the real properties of the complex system and those of its simple counterpart. Such a deviation is what we traditionally call error or variability. I will argue that every form of error arises in this fashion, and is the inevitable consequence of our perception of a complex system in terms of individual and completely separable functional activities.

We have said that error *arises* from a deviation between the behavior of a simple system and one corresponding activity of a complex system to which the simple system is likened. But there is another way in which error can be viewed, and that is in terms of appropriateness for reaching some intended goal. Thus a particular kind of functional activity is called *erroneous* or *mistaken* if it will not carry the system from its initial state to its desired end state or goal. It is

the relationship between these two views of error which introduces the notion of evolution into the behavior of complex systems.

Let us suppose that we have a set of similar complex systems, such as a population of organisms initially exhibiting the same response to a particular environmental stimulus. Let us suppose that this response is an appropriate one, so that we may say that the organisms are behaving correctly. Since the organisms are complex, they can interact with the environment in diverse ways besides the one we regard as the stimulus, and these interactions will affect the way the organisms are responding to the stimulus. Thus, over time, the initially identical response pattern of the organisms will become a spectrum of different responses some of which are still appropriate and some of which are not appropriate or erroneous. Here, of course, the propriety of a response is judged by some criterion of selection which is imposed on the population. If the criterion is changed, so too will the propriety of any particular response, It is easy to see that the change in selection pressure, which makes previously correct responses no longer appropriate, and which makes previously incorrect responses become appropriate, would wipe out a population which could *only* make the initial response. In this way, it is correct to say that error is a driving force for evolution. A population of simple organisms could not evolve and indeed could not survive a change in selection pressure. Thus, evolution, error and complexity are concepts which are inextricably linked to each other.

Let us now return to a consideration of the cultural models outlined above, with an eye to seeing how the concepts of error we have introduced enter into those models. There are two aspects to be considered; first, the deviation of the behavior of a real cultural system from any simple model of that system and secondly, a pressure of selection which will determine the appropriateness or inappropriateness of this behavior.

The cultural model we presented is a deterministic model, although fluctuations and perturbations can be imposed on it. However, this model is one which is constructed from the standpoint of an *external* observer of the culture. We have already pointed out that the members of the culture will, from their *internal* standpoint, make their own models of the culture, and that the more differentiated the culture is, the more different these internal models will be from each other. Each of these internal models represents only a simple system and therefore, it is to be expected that the behavior of the culture as a whole will be different from all of them. This is a simple corollary of the basic premise that the culture is complex.

The deviation of the actual behavior of the culture from the internal models made by members of the culture will be interpreted by them as errors. From the standpoint of the external observer, however, it is not yet possible to describe the behavior of the culture in these terms. In order for the external observer to conclude that a particular behavior is erroneous, he must consider the appropriateness of the behavior in a particular set of environmental circumstance, That is, he must introduce a notion of selection and selection pressure.

Let us spend a moment discussing the nature of selection. The external world acts both to impose stresses upon a culture and to judge the appropriateness of the response of the culture as a whole. The external world thus sits in the position of an outside observer. Since selection acts on the culture as a whole, there is only an indirect effect of selection on the members of the culture and hence on their internal models of the culture. This is, indeed, a characteristic property of aggregates like multi-cellular organisms or societies; namely, that selection acts not directly on the individual members of the aggregate, but on the aggregate as a whole, We have seen that the behaviors of the aggregate as a whole are not clearly recognizable by any of the members of the aggregate and therefore none of the internal models of the aggregate can comprehend the

manner in which selection is operating. Stated another way, the members of a culture respond primarily to each other, and to each others' models, rather than to the stresses imposed on the culture by the external world. They cannot judge the behavior of the culture in terms of appropriateness at all, but only in terms of deviations from their internal models.

Let us consider a specific example of a fairly differentiated culture for which environmental circumstance change. Let us consider a culture behaving appropriately under a particular set of meteorological conditions. Let us suppose that these conditions become much more arid over a short space of time, clearly, the old behaviors related to subsistence will now become inappropriate. From the standpoint of an external observer, the culture as a whole should respond to the changed situation either by developing new technologies (connected with irrigation and water conservation) or it should migrate to a new region in which its old behaviors will continue to be appropriate. However, if the internal models of the culture are such as to inhibit the developments of the new technologies and/or of the necessary migration, the culture as a whole would be seen to be producing a wholly inappropriate response, even though from the standpoint of those internal to the culture, there is no error. In this example, we can see quite clearly how inadequate the internal modes of the culture can be in deciding the erroneousness of cultural responses to external stress. The converse of the above example is also true; namely a particular cultural behavior can look erroneous to all of the members of the culture on the basis of their own internal models, but that behavior can be perfectly appropriate from the standpoint of an external observer.

We thus see how great may be the departure between appropriateness (which is an external concept, involving the culture as a whole) and the deviation from internal models of the culture (which in general cannot grasp behaviors of the culture as a whole). If decision-making within the culture is thus made entirely on the basis of internal models, there is very little chance that these decisions will result in appropriate behavior. The only remedy for this situation seems to be the one adopted by multi-cellular organisms. In this situation, the multi-cellular aggregate itself becomes capable of sensing and responding to the environment directly, and thereby of developing a *model of the external world* itself. This must involve a new level of organization, because without it, the members of the aggregate can only have models of each other and not of the external world. Indeed, the whole point of a culture is to prevent the external world from impinging directly on its members. At the present stage, it appears that our own kind of culture is very far from developing his kind of organization. Indeed, we have very little experience for seeing how to go about this process except that which we can extract from appropriate studies of multi-cellularity. It is clear that even if the culture as a whole can successfully make models of the external world, and thereby become capable of evaluating cultural responses in other terms besides deviations from internal cultural models, there is no guarantee that behavior so generated would be appropriate. Indeed, most species of multi-cellular organisms are now extinct as a consequence of behaving inappropriately. Nevertheless, the chances for survival are far greater in the presence of a mechanism to sense appropriateness than in its absence.

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