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DOES STRUCTURE MATTER?

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Abstract

Theories of country systems include structure, rules and their consequence on structure, emotion, and stages. Structural theory, including analysis based on the effects of rules, emotion or cognition on forms of networks, does much more than merely describe. It also predicts properties of systems, which can be observed empirically both as descriptions of events and processes, and as examples of historically documentable changes. Certain cultural structures computed from rules are examples of butterfly architectures known from design of parallel processors. This has important implications for the value of rule-bound theory, and for systems theory generally when applied to country or cultural systems.

1. Introduction

Among the principal questions about country systems are "how are they shaped", "why are they shaped that way" and "when and how do they change". These same questions also arise for any cultural system, of which countries are simply among the larger examples. At least three kinds of answers have been given to these issues: structure, including rules and their consequences on structure (such as Ballonoff, 1994), emotion (for example Koizumi 1994) and stages (for example Mulej 1994, or Campbell 1994 which discusses "structure" but actually describes sequences or stages).

Superficially, structure theory seems purely descriptive, emotion theory seems unrelated to structure at all, and stage theory seems to answer questions of process and change. But reality is the opposite of these impressions. Structural theory encompasses all of description, and prediction of how process affects, and is affected by the system described. Structural theory also provides predictive capability for paths of country development. Stage theories are only descriptive, and of that only of historic events -- they have little predictive value outside of a theory of structure. But emotion theory is also structural, since emotions describe behaviors, which result in processes, which are structured events. Emotional explanations of cultural events are simply structural theories of the effect of cognitive process on organization of groups.

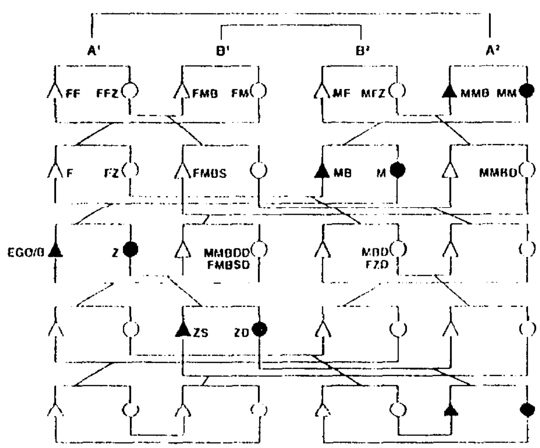
2. The Task of Theory in Country Development

The purpose of theory of culture, including of country development, is to provide means to answer the how, why and when questions. This requires a means to describe what exists, to predict when the objects described will exist, and from that description and predictive ability to also predict when and how the described condition might change.

3 An Empirical Example

Previous papers in this series have argued that cultural structures are best described as sets of rules and of objects subject to, or generated by, the operation of those rules. To see this it is useful to summarize the work of anthropologist Robin Fox in the analysis of systems or marriage (Fox 1967 especially at about page 217, and Fox 1994 at pages 199 - 213). Fox was initially interested to describe and compare the structures of marriage systems of native groups in Australia, and like many ethnographers or social anthropologists, thus described the effect of the rules using the smallest regular diagram which would also depict the action of the rule in question.

One of the problems to be solved was that there were many different ways to describe what "the tribe" was "doing". All of the following verbal descriptions were asserted, and which, at first sight, seem different: required marriage of a male to the matrilateral first cross cousin female (the daughter of the mothers's brother); a two clan system with "exchange" of wives between the two clans or "moieties"; a four clan system with required "circulation" of wives between the four clans in a regular order. Fox analyzed this into a system represented by the diagram below (diagram 12.3 from Fox, 1994). The diagram uses standard anthropological labelling: circles represent women; the triangles represent men; lines connecting circles and triangles from above show brother-sister pairs; lines connecting circles and triangles from below show marriages; angled lines connecting marriages to sibling pairs in the layer below show descent lines for purposes of the marriage rule. The lettering "MF" etc. identifies kinship relationships in standard English terminology, relative to the individual labelled as "ego", except that "Z" is used to label "sister". Thus, "MF" means "mother's father", etc.



A Four Section Austrialian Marriage System
(Adopted from Fox, 1994 at page 204)

Notice that this diagram meets all of the required descriptive criteria. There are two moieties, A and B, consisting of two clans each, A1, A2, B1 and B2 for a total of four clans. Tracing the labels of the columns in which the circles fall, one sees that the sequences of marriages are always A1 male marries B2 female; B2 male marries A2 female; A2 male marries B1 female; B1 male marries A1 female. Also, therefore the "females circulate" (as the anthropologists sometimes say, but inherit labels, to be more literally accurate) in matrilineal descent lines over generations in the sequence of clan names A1 > B1 > A2 > B2 > A1 etc. Also, each marriage is between a man and his matrilateral second cross-cousin.

Also, though without adding the detailed analysis here, the picture shows exactly the minimal structure for this system as analyzed in (Ballonoff 1987, Appendix 1). That is, the system is the smallest which depicts the rule while reproducing an identical configuration in the shortest period of time. Also, and saying the same thing in different words, the picture of each "layer" or generation is isomorphic to each other generation. When diagrammed in the style of Ballonoff 1987, it is further apparent that each layer is "rotated" 90 degrees from the one above, so that the figures are isomorphic including only rotation each third generation, and isomorphic including the labels each fifth generation. This fact is useful in interpreting the parallel architecture noted below.

There are other verbal descriptions consistent with parts of the diagrams and not with others. For example, if one retains all of the above structure and then prohibits marriage to the patrilateral cross cousin at the same time, then another diagram, of the same size results. This is part of why Fox wrote at least two articles on the subject; and why there are other 1-stable minimal structures in the style of Ballonoff 1987, of the same size. These facts only reinforce the present point, and do not need further discussion here.

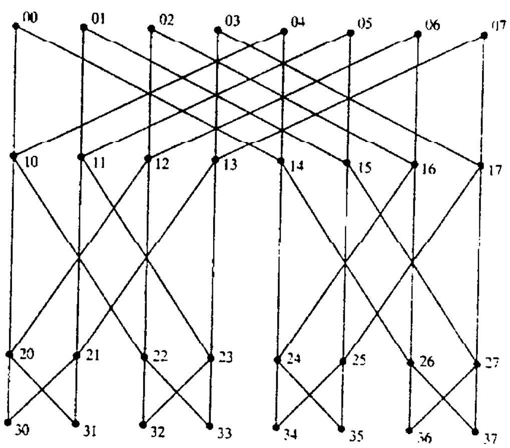
Regarding these structures, one may ask if any Australian tribesman knows about the structure. Fox says "No one has to know how the whole system works - although Australians are as adept as anthropologists at diagramming and describing their systems - but only what one's own rule of marriage is, and that is quite simple" (Fox, 1994, page 206). This is also consistent with the distinction between culture and structure made by Geertz: "Culture is the fabric of meaning in terms of which human beings interpret their experience and guide their action; social structure is the form that action takes, the actual existing network of social relations." (Geertz, 1973, pages 144-145).

4. Parallel Systems Theory as A Theory of Cultural Structure

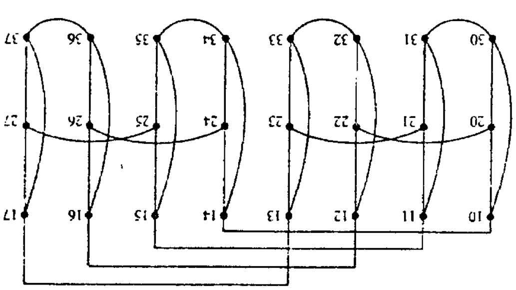
Previous papers in this series (especially Ballonoff 1994, 1995 and 1996) argued that cultural theory is analogous to the mathematical theory of temporal logic of concurrent operating systems. One consequence of concurrent design of parallel operating systems is a design called "butterfly architectures" (Krishnamurthy, 1989 especially at pages 230 - 237). Butterfly architectures are among the class of algorithm-structured architectures, applied in the design of massively parallel processor systems to reach efficient sorting, fast Fourier transform information processing, and to permit simplified programming which permits program statements to self-order with least complexity.

Getting straight to the point, depicted first below is a representation of a butterfly architecture of 8 columns and 4 rows (32 processors). The similarity of the diagram to the marriage system represented earlier is only impressionistic until one also learns that butterfly architectures can be topologically equivalent to cube connected architectures of processors (Krishnamurthy at page 233). The second picture below represents a cube connected architecture which is topologically equivalent to the previous butterfly architecture, except that the first and last rows coincide. That is, the cube connected architecture is a butterfly architecture of $2^k(k+1)$ processors in 2^k columns and k+1 rows, in which the 0 row and the k-th row are identified. In the above butterfly example, this is the same as to identify the top row with the row whose labels are initiated by 3 (for k = 3).

Butterfly Architecture, 8 columns, 4 rows, k=3
(adapted from Krishnamurthy, page 232)



Cube connected Topology of The Same Architecture
(adapted from Krishnamurthy, page 233)



The cube connected example is intentionally inserted "upside down" from that in the source text. That is because the mapping required to see the identity of the marriage system to the butterfly architecture (in its cube-connected topological equivalent) is: to identify the "horizontal" lines in the cube diagram with the brother-sister pairs of the marriage diagram; to identify the "vertical" lines of the diagram with the labels of descent of the clan names; to identify the even numbered nodes as "males"; and to identify the odd numbered nodes as "females" (or vice-versa). Then it is apparent that the labelling of the third level are 180 degrees away from the labelling of the first layer (as would be required by the labelling isomorphisms in the style of Ballonoff 1987), but that otherwise the pictures are equivalent. The marriage diagram shows principally the labelling information but lacking some topology, while the cube connected version of the butterfly diagram shows the topology but lacks some of the labels.

Butterfly architectures are also similar to structurally programmable systems, in that the networks generated in a butterfly architecture mirror the structure of the algorithm used to generate the structure (Krishnamurthy at page 234). A previous paper (Ballonoff 1995) argued that human cultural systems are structurally programmable. It is also known in parallel processing (from Krishnamurthy) that the best results are obtained when the program and the machine graphs are isomorphic, which is also a property of a structurally programmable machine.

The numerical properties of the butterfly designs and the minimal structures of marriage systems are also related, though that topic is not explored here in depth. For example, for a cultural rule system with structural number s, which is to say the number of marriages (or sibship pairs) in the minimal representation of a rule is s, then the number of column-pairs in the butterfly network is equal to s. The number of processors in each row of the architecture is equal to 2s. Apparently also, k = s - 1. Among other uses, k is apparently also the number of layers needed to make the statistical computations for population dynamics of rule bound systems, as illustrated in the examples of Ballonoff 1982a and 1982b. In general, in the cultural analysis the structural numbers are found as a result of analysis of the rules of the system, while in processor design they relate to the efficiency of the network.

5. Implications

There are many important implications of these results. Another paper (Ballonoff 1996) in this series demonstrates that the rules systems of cultural theory are reducible to the unique minimal configuration for that rule. Not incidentally, this occurs because the traces of the matrices which represent the rules are equal to 0, a property which is completely a result of the nearly universal presence in human systems of cultural rules of exogamy (non intermarriage) within the most local descent group.

Therefore, the properties which make minimal representations of the rules systems of cultures into butterfly architectures are very fundamental properties of the rules systems of the culture, as well as of the empirical structures which result from the operations of those rules.

Structural programmability is another way of saying that the behavior or experience of the system is used to map the rules and predict future behavior. Cultures therefore act like a self-teaching machine which uses its own experience for creating analogies that become the rules system of the culture. This is essentially also the position of anthropologist Claude Levi-Strauss and others of the classical French school of sociology, on analysis of human systems of myth and analysis of pre-literate systems. (Levi-Strauss 1964, 1966; also for example Durkheim and Mauss 1954).

The reason why butterfly architectures occur in both processor design and in natural human systems appears to be information processing efficiency of the resulting networks, in both cases. In the cultural systems, part of the efficiency is in "naturally adaptive self-learning systems". These are systems which create rules based on their experience and then communicate by analogy (features both of the French school of analysis and also expressed by "structural programmability"). In parallel processors, the greater the similarity of the rule systems (cultural systems), that is, the greater the degree of their isomorphism, the lower the cost of communications within the system. Thus, the human systems are also efficiently "self-organizing", as demonstrated by the result that their structures are efficient for similar purposes in parallel processor design.

The adaptability of the rules systems and their ability to change in efficient ways also determines the survivability of the system. This was argued for cultural rules by (Ballonoff 1994) and for the co-evolution of cultural rules with biological environments in (Durham, 1991). This has many additional implications.

This, and also structural programmability are also properties of the "universal expert systems" of the self-teaching intelligent machines described in the work of (Ezhkova such as 1989a, 1989b). Therefore, one may predict that any efficient set of rules generated by a successfully "artificially intelligent" machine which is also recognizable as human will have both minimal structures and representations as butterfly architectures. Therefore, such machines will also have "cultures", and probably be able to communicate among themselves using the structurally programmable features of the rules -- that is, of their experience! -- as is also implied by the logic of the machines described by Ezhkova.

Because butterfly architectures are also representations of fast Fourier transforms, which are examples of mathematics highly dependent on mathematical groups, this lends support to the "group axiom" speculation of (Ballonoff, 1994) that human systems of rules will be representable as mathematical groups of operators.

Because the rules determine the possible sequences of structures, and because the statistical theory implied by these rules uses the Second Stirling Number, not the First (Ballonoff, 1987), then supposedly "dynamic" theories based on thermodynamic models (which all inherently use the distributions based on the Stirling Number of the First Kind) do not determine the viability of structures nor therefore their historical duration. Therefore, in particular, "chaos" and other theories which are based on thermodynamic models are not predictive of historic sequences. But because cultures do depend on real physical processes, physical models of those processes relate to the physical flows of materials as configured by the cultural objects. Therefore, models of efficiency (as from microeconomics or thermodynamics) can be used, in connection with other facts, to predict limits of possible presence of certain cognitive structures (rules systems). However, the fact that an analyst of or a participant in a system is confused does not imply that the system is in chaos in any technical sense. That physically based theories have been often relied on for political purposes however, helps explain the historic, and often tragic, consequences of recent political ideologies for management of country systems based entirely on mechanical models of society.

6. Conclusion

The main point of this paper for analysis of human country systems is that the different modes of analysis of human cultural systems are not distinct from each other. In the above diagrams, patterns or configurations of network connections will recur in cycles, over several generations. One could easily describe these as "stages", or as "instances of a structure", or as "results of actions of rules", or even as purely emotional "loves" or "avoidances" among particular clans. But one must also be careful in use of these descriptions. The mere fact that a particular set of structures occurs in some historical sequence does not mean that the sequence will repeat, or can be used to predict sequences of "stages" in the future of some other human group in which the existence of some similar structure may be observed. Instead, it is necessary to examine the particular rules in use, and to determine whether and how they are changing, in order to predict future states of configurations.

For that reason, the more fundamental form of analysis is to understand the rules of action (including of emotion as well as of logic), in order to compute the possible structures which may result. The resulting observed historical "stages" are merely artifacts generated by the internalized "cognitive" rules of behavior. The existence of configurations however can be taken as evidence of past states of the rules. The existence of past sequences of configurations (histories, or past sequences of "stages") can be taken as evidence of previous changes in, or the previous stability of, those rules.

References

[Ballonoff, 1982a] Paul Ballonoff. Mathematical Theory of Social Demography. In Robert Trappl, editor, *Progress in Cybernetics and Systems Research* Vol. X. Pages 101-112. 1982.

[Ballonoff, 1982b] Paul Ballonoff. Mathematical Theory of Social Demography, II. In Robert Trappl, editor, *Cybernetics and Systems Research*. Pages 555 - 560. 1982.

[Ballonoff, 1987] Paul Ballonoff. *A mathematical theory of culture*. Monograph No. 40, Austrian Society for Cybernetic Studies. 1987.

[Ballonoff, 1994] Paul Ballonoff. Theory of Rule Bound Human Systems. In Stuart Umpleby and Paul Ballonoff, editors, "Cybernetics of Country Development", special issue of *Cybernetics and Systems, An International Journal*, Volume 25 No. 6. Pages 837 - 860. 1994.

[Ballonoff, 1995] Paul Ballonoff. More on the Mathematics of Rule Bound Systems. In *Cybernetics and Systems, An International Journal*, Volume 26 No. 2. Pages 129-132. 1994.

[Ballonoff, 1996] Paul Ballonoff. Comparison of Rule Bound to Traditional Systems Theory. To appear in *Cybernetics and Systems, An International Journal*, 1996.

[Campbell, 1994] David F. J. Campbell. European Nation State Under Pressure: National Fragmentation or the Evolution of Suprastate Structures? In Stuart Umpleby and Paul Ballonoff, editors, "Cybernetics of Country Development", special issue of *Cybernetics and Systems, An International Journal*, Volume 25 No. 6. Pages 879 - 910. 1994.

[Durham, 1994] William H. Durham. *Coevolution: Genes, Culture and Human Diversity*. Stanford University Press. 1991.

[Ezhkova, 1989a] Irina V. Ezhkova. Knowledge Formation Through Context Formalization. In *Computers and Artificial Intelligence*. Volume 8. No. 4. Pages 305 - 312. 1989.

[Ezhkova, 1989b] Irina V. Ezhkova. Context Formalization Based on the Concept of Universal Scale. In *Proceedings of the Third World Congress on Fuzzy Sets*. Seattle, Washington, USA. 1989.

[Fox, 1967] Robin Fox. *Kinship and Marriage, An Anthropological Perspective*. Cambridge University Press. 1967.

[Fox, 1994] Robin Fox. *The Challenge of Anthropology, Old Encounters and New Expressions*. Transaction Publishers. 1994.

[Geertz, 1973] Clifford Geertz. *The Interpretation of Culture*. New York, 1973.

[Koizumi, 1994] Tetsunori Koizumi. Nationalism as Ideology, Nationalism as Emotion, and the Pitfalls of National Development. In Stuart Umpleby and Paul Ballonoff, editors, "Cybernetics of Country Development", special issue of *Cybernetics and Systems, An International Journal*, Volume 25 No. 6. Pages 747 - 762. 1994.

[Krishnamurthy, 1994] E. V. Krishnamurthy. *Parallel Processing, Principles and Practice*. Addison Wesley. 1991.

[Levi-Strauss, 1964] Claude Levi-Strauss. *Totemism*. Merlin Press. 1964.

[Levi-Strauss, 1966] Claude Levi-Strauss. *The Savage Mind*. Wiedenfeld and Nocolson. 1964.

[Mauss and Durkheim, 1954 translation] Marcel Mauss and Emil Dirkheim. *The Gift*. Glencoe, Illinois. 1954.

[Mulej, 1994] Matjaz Mulej. Dimensions of Change During Development from a Preindustrial to a Modern Society. In Stuart Umpleby and Paul Ballonoff, editors, "Cybernetics of Country Development", special issue of *Cybernetics and Systems, An International Journal*, Volume 25 No. 6. Pages 911 - 930. 1994.