**Heinz von Foerster's Self Organization,
the Progenitor of Conversation and Interaction Theories**

Contents

Index, Table of Contents added by Nick Green

Last corrected 22nd. July, 2004

Queries to nick_green@blueyonder.co.uk

• *Research Paper*

Heinz von Foerster's Self Organization, the Progenitor of Conversation and Interaction Theories*

Gordon Pask

System Research Ltd, Old Town, London, UK

Dear Heinz and Mai,

In the late 1950s we worked on self organization together. And since then we have worked in sympathy.

My own theories-of conversations and of the interaction of actors-come from that work. In fact, it seems to me now, they come as much from your work as from mine.

What I present before you in this Festschrift is the story of how my own ideas first burgeoned from understandings you first brought to life, and grew to fully fledged theories. I expand these into mature form to present the results of this generation which, as you know, I call 'conversation theory'. Again, taking some of the constraints of conversation, I de-limit them-as you have shown me how to do-to give the basis for my 'interaction of actors theory'. In the middle I place an axiomatic presentation which I have made for you. It conjoins and extends the theories. It is intended both as a bridge and a unification.

I end with something decidedly personal: 'conversation and generation'-for you are not an ideas machine. What I get from you I get because you made the ideas: to adopt (and adapt) you 'objectivism is the delusion that ideas can be made without a maker (and can be enacted without an actor)'. In this case it is the interaction of actors.

This offering is abrupt and fragmented for it is limited to be but a paper. It may be that it is not understood. If it is not understood I shall be sad. But what is important is that you understand it. And I am sure you will.

Dear Heinz, this paper comes to you with love, empathy and *sympatie*.

Gordon.

*This paper is the last paper written by Gordon Pask before his death on the 29th March 1996. It was very important to him to write this paper, both as the tribute he had longed to pay to his friend and mentor Heinz von Foerster, and because writing this tribute gave him the chance to put together the main elements of his work so that some of the coherence he saw could be indicated to others, with a new meta-theoretic position emerging (see the section 'Axioms and Other Postulates' set in a different typeface). It went through very many versions as Pask struggled against illness and the tremendous demand he was placing on himself, to complete the text, and I believe that his need to make this statement was one of the things that kept him alive. He posted me the last version on March llth, and this is the version that appears here. I have decided not to modify the paper in any way except by spell-checking and punctuating. It stands as it was sent to me. I believe it is as clear as Pask could make it, even it if is somewhat fragmentary. Indeed, I think the fragmentation is part of its charm and is appropriate to what is being said (in as far as I understand it). The lack of a glossary of terms was Pask's choice. The paper in the form it takes here is the result of many hours of humble reflection by Pask: humble in that he sought and listened to much tough advice, and humble in that it was written through love in the face of death. It is a remarkable document and is, I believe a fitting testament of how Gordon felt about Heinz and to Gordon's life of creative struggle, also.

Guest Editor

Heinz von Foerster's Self Organization, the Progenitor of Conversation and Interaction Theories

Gordon Pask

System Research Ltd, Old Town, London, UK

Over more than three decades Heinz von Foerster and I have collaborated and worked together as well as in separate laboratories. This contribution gives a terse account of work which we have done together and which is relevant to Heinz' prescient notion of self organization and its many arborizations. In the course of doing so it spells out some of the history associated with cybernetics to which both Heinz and I adhere.

Keywords concept; conversation (theory); interaction (of actors theory); observer; P-individual; self-organization; spin.

INTRODUCTION

This contribution might be called alpha to omega to infinity. Why is that? Alpha marks the beginning of active co-operation and liaison between Heinz von Foerster, my immediate colleagues and myself. Omega marks the current situation and since neither of us has ceased to create or to think, it is an indication of what is to come, since all theories worth their salt evolve. It is possible to demarcate several eras. For example, the era of adaptive machinery at point alpha and the notion of self organization as proposed by Heinz von Foerster. During that period a great deal of work took place and although Heinz remained the same in spirit, his repute, or flag, if you like, has undergone certain transitions. For example at alpha he was known as a physicist and at point omega he is known as a group or family psychotherapist. That is the popular image. The transition was not continuous and not all of the discontinuities are charted in this contribution. For example, there was a period when our interests veered towards epistemology, anthropology, group interaction and consequently conversation and the interaction of actors. That is why there is such a close liaison with self oganization attributable to Heinz and conversation theory (CT) and inter-action of actors theory (IA) to me.

In the course of the discussion it is possible to trace the evolution of cybernetics, to which both of us adhere, and to observe a transition between first-order cybernetics and second-order cybernetics as they are currently known. Also, it is possible to show the resilience of cybernetics, although it permeates all sciences, and its identity may seem, to some people, lost. It has survived the zany and puerile epochs of cyber-punk the tedious and repetitive taxonomies which accompany any science and the politically necessary changes in title. For example, there was a period when one could not speak of cybernetics but only of bionics, information science or general systems theory. These changes have been related to our joint or mutualistic work.

SELF ORGANIZATION

In 1958 or thereabouts the small town of Namur, a provincial capital in Belgium standing on a large hill at the bifurcation of the rivers Meuse and Sambre, was a meeting place for the International Cybernetics Association. Right at the top of Namur is the hotel Chateau de Namur. It is connected, either by a teleferique which met with a mishap (nobody was hurt but the teleferique was dysfunctional) or by a tortuous road around the mountain, which I alluded to as a 'hill', which is the Citadel of Namur. It is a citadel since it is penetrated with a labyrinth of passages and the road around is precipitous. The passages are like Gibraltar; with a military ballroom, even, hewn out of the rock. From the top you come down to the Hotel Comte D'Harscombe or, lower still, to the railway station, the Place de la Gare where there is the Hotel de Flandres and in those days, at least, the Hotel Coq D'Or in the cafe of which I was sitting. I had just had a beautiful argument with Marvin Minsky in the Chamber of Commerce, as a result of which we became firm and lasting friends. Heinz von Foerster appeared at our table as a magic figure. I have written a short tribute to this

aspect of his character on his retirement for the American Cybernetics Society Forum called 'The Importance of Being Magic' (Pask, 1980) and shall not stress it in this contribution.

But he is magic. Yes, he is a conjuror and knows the tricks of legerdemain and also the skills (for example, he can ride a monocycle around a casino or cabaret floor while putting on six hats, one on top of the other). He is also a radio announcer. He is an eminent physicist, having written papers both biological and physical on, for example, memory not being stockage but being *memoir*.

The magic I intend to deal with lives amongst many curious and enigmatic subjects of his attention: it is that of self organization. I refer you to 'Observing Systems' which is a sensible, sensitive collection of his works edited by Francisco Varela. Although I intend to deal with the chapter on self organizing systems, I invite you to read the lot.

Heinz described self organization in a seductively respectable way. He used the entropic information measure of Shannon, namely H, and the entropic information which a system could possibly have, that is $Hmax$. He pointed out that a ratio measure, redundancy, $R = 1 - H/Hmax$, is an appropriate measure of organization and that a system is self organizing if and only if $dR/dt > 0$. Now H is clearly related to one of the measures of the fractal dimension of a point set and R is one of several ratio measures of the sort that are used in determining the efficiency of heat engines. Taking this measure he proceeded to differentiate it with respect to a quantity called time. This sounds terribly respectable until we realize that H and $Hmax$ are, a priori, independent variables.

It is deductively true that in order to be self organizing the entropy H multiplied by the rate of change of maximum entropy d$Hmax$/dt should exceed a value greater than the maximum entropy multiplied by the rate of change of entropy dH/dt. It is a simple condition and one that went unquestioned at that stage (rather disappointingly so). It naturally brings to mind adaptive systems becoming more or less ordered or more or less disordered. In fact we may appeal to Schrodinger's delightful 'What is Life?' (Schrodinger, 1947), his inaugural lectures at Dublin. Here he talks about order from order and order from disorder, as does Heinz. He thinks of life or, if you prefer it, self organization, as being something of this kind.

In addition, however, Heinz introduces a further commodity i.e. 'noise' in the sense of Shannon. 'Noise' stands for undifferentiated energy (although the point is made more clearly in later papers in the same reference volume such as 'Molecular Bionics'). He further exemplifies the limiting condition for self organization by shaking (an undifferentiated energy) a box of magnetised cubes or other geometrical forms and of different species with respect to their magnetic faces. If these annul or if the cubes are non magnetic there will be disorder. If they are oriented in such a way that they may stick together like the droguli of Penrose and O. D. Wells, the system becomes almost completely ordered and crystalline. These are the limiting cases of self organization ($R = 0$, $dR/dt = 0$).

It is very convenient to think, as von Foerster does, of the fundamental variables of H and **Hmax** as being regulated by demons and, for example, H being determined by the prior values of dH/dt and $Hmax$ by the prior values of $dHmax/dt$, the demons pulling the necessary levers or knobs. However, that would be an uninteresting resolution and could be no more than an adaptation. The reality is that what has to be maintained is the previously stated balance between ratios: the demons governing H and $Hmax$ and their change are asynchronous because **H** and **Hmax** are independent, a priori, and so are the demons.

Really, interesting self organization comes about so far as the demons are coupled and learn about each other and each other's environment, this coupling being accomplished by a Petri-type information transfer. For me, at least, the interaction of the von Foerster demons is paradigmatic of a conversation between two participants.

Amongst other consequences, an observer who comes to know the system must be a participant in the system. The boundaries of the system, far from being pre-fabricated, are created by the activities of the system. This is a prescient notion of autopoiesis (as developed by Maturana and Varela), or organizational closure, as we called it at Brunel University and in my own laboratory, System Research.

Self organization is an important and very useful discovery. It was particularly useful as I shall now indicate: in the context of our research programme which sought to find subjectively hard data, in particular in the field of adaptive systems for regulation of perception, learning and innovative processes on the part of people and groups. But our sights were set further; we wished to adumbrate organizations of all kinds: industrial,

biological, societal, and so on; which is the rationale (later on) for a discussion of P-individuals (psychological individuals) and M-individuals (machine individuals rather than necessarily biological ones). Sadly in that era (the late 1950s and early 1960s) attempts to maintain a status for this work were apt to be rejected as fanciful or not objective (they certainly are not objective) and unscientific (I am inclined to deny this). It was necessary in this situation to demonstrate in a way acceptable to the established order that conversations did occur and that consciousness was aroused, to address the notion of consciousness in an informative though not explicatory manner and at least hint upon the notion of awareness. To do so was manifestly a large project and the labour involved could hardly have been justified had we concerned ourselves with education, the particular field of inquiry, alone. Or, indeed, of experimental psychology, which is inclined to misapply statistical methods in the name of science or to neglect the presuppositions truly involved.

Hence we embarked upon an unashamed search for and to some extent discovery of what consciousness is and how it may be manipulated other than by giving an anaesthetic or bashing people on the head with a club and making them concussed. We set up a system of interaction between participants through a mechanized interface.

It is possible and more efficient to perform this operation using human participants and the techniques of hypnosis or of Piagetian interview or the like. However, this would not have pleased the establishment who wished to have behaviours recorded and statisticised in some way. To accomplish this we resorted to adaptive machines which were not digital computers (this was before the computer generation). Our programs were probably more elaborate than current programs on computers and they were used widely both in the field and in the laboratory to regulate learning, innovation, perception, repetition, self-consistency, overload and training. In this we recognized throughout that our interaction was a model of the interaction between von Foerster demons in a self-organizing system and that the phenomena we observed were those supporting the verification of this principle.

Apart from the empirical work, the theoretical load was considerable-though the idea of self organization as a primary issue in mental or social activity was consistently affirmed. The type of experiment we did, for example in the context of learning, was to set up an interaction through an interface (as before, it would have been more efficient to use a participant experimenter such as the Piagetian interviewer). (The paraphernalia of the learning and looking system such as CASTE-Course Assembly System and Tutorial Environment-and other systems we developed is completely unnecessary, in practice, except for professionals anxious to do away with your conceptions.)

The results of these early experiments and those carried out throughout the 60s and early 70s were generally positive. They were the precursors for mesh and interface experiments and involved adaptive machines.

Thus the adaptive system achieved, in concert with the participant, a higher rate of learning, a greater efficiency of learning, a self-consistency which if fed back on the mechanical environment, increased its diversity. The participant was obliged to signify this fact and the diversity was reduced. However these positive results-positive in the sense of the establishment-were accompanied by a negative and much more interesting result. As you increase the elaboration of the adaptive machinery enabling it to adapt hierarchically, for example, to several levels and to have a vector of reactivity, which is extensive up to say eight or nine variables that are related in the hierarchy, you appreciate that something odd is happening. The participant either gets bored (which is very natural) and opts out of the experiment, or preferably opts out by playing with the adaptive system. The more elaborate this system is, the more it can be 'programmed' by the participant, rather than 'programming' the participant.

For example, in an adaptive training system it is the correctness and rapidity of response which is fed back to the adaptive system, in order to increase or decrease task difficulty. In a system constructed to maintain attention an index of self-consistency replaces correctness and can be used to introduce or reduce any learnable rules in a mechanical environment (removal of rules increases the diversity and vice versa as well). Some model of how the participant learns, mentates and arouses attention must exist in each case. The adaptivity of the system can be and is improved by searching among a collection of models and selecting the one (if any) best suited to the participant and his or her mental repertoire.

The elaboration in the machine of his or her mental model is, however, limited by the finitary constraints of the system. The form of constraints is given away by the use of terms like 'hierarchy' or 'input' and 'output' (assumed to remain invariant and consequently fixed by the design of the system). They are allowed to vary only as a designer

prescribes. The participant is simply thwarted and his or her mental repertoire cannot become manifest in such a system.

It was necessary for us to show that such strict interactive conditions must indeed prevail. That self organization is not adaptation or habituation or some tawdry form of learning in the sense of mathematical learning curves. It is in fact a fundamental paradigm which merges and forms a bridge between the old cybernetics and the new.

The old cybernetics has been elaborated ad *infinitum.*

The new cybernetics (some call it second-order cybernetics in contrast to the first order of classical black boxes and negative feedback) is burgeoning well beyond the bounds of respectability which were imposed by the establishment. If interaction, albeit interrupted by a phone call or a business trip, is unfettered in intellectual flow, I call it a conversation which leads to the exchange of concepts, not necessarily of the topic, but of the participants. It may or may not be about whatever is the alleged topic of conversation. Later we consider interaction of a broader kind, the interaction of actors. Conversations are events which have a beginning and have an end and may be subdivided into kinematic portions, in contrast to interaction of actors which cannot. Comparable notions have been mooted by Petri, Glanville and others.

SOME DETAILS

People like Heinz do not in essence change. However, their interests and reputations do fluctuate in a material way. For example, Heinz explored at one stage biological and brain neuro-physiology. The particular transition in reputation and orientation of thought which I intend to deal with is a different one. It did not occur continuously, as I am writing it down, but in small jumps with small groups and it went on from small groups regulated through (not by) a machine. Soon this interest, which started with group interaction through (not with) a machine, matured into an interest in small groups held together by normative constraints-paradigmatically, families. Hence it was not surprising that Heinz became concerned with group psychology and anthropology (along with Gregory Bateson) and families. In particular, in the atmosphere at that stage, he became known for family psychotherapy. This led to an orientation toward such phenomena as the 'double bind' and 'alienation'. Let me emphasize that in no way did Heinz discard his other interests and origin as a physicist. But it is very reasonable to notice that his fundamental focus of attention was a conversation. At which point we united as social psychologists and cyberneticians, since conversation is the principle medium entailed in the interaction of members of such groups. A serious study of this matter requires a fundamental re-orientation towards concepts, their character and exchange. In order to explicate this I intend to introduce some definitions which will be of value in interpreting the transition in the reputed position of Heinz von Foerster and to relate self organization very closely to conversation theory (CT) and interaction of actors theory (IA). The definitions are as follows.

Algorithms or programs are labeled, what-ever they are, by what they achieve, possibly a set or collection of entities thus:

(a) *PROG(T)* where *T* may be anything, e.g. a tower, dog, etc. That is anything that may be pointed at or ostended.
(b) Let a participant be the ordered pair <P-individual, M-individual> indexed by a sub-script z with values such as *A, B, ...,* standing for different participants.
(c) Participants are capable of interpreting an otherwise inapplicable PROG so that we may write $PROC_Z(T)$ = <*PROG(T), INTER_Z* > where $z = A, B, ...,$
(d) The $INTER_Z$ is the interpretation on an occasion by a participant z.

Consider now the formation of a concept in greater detail because that, after all, is what is shared wholly or partially in a conversation.

Let *PROG(T)* be a program or if you like an algorithm for achieving *T*, whatever that may be. Let *PROG(T)* be not equal to $PROC_Z(T)$ which, however, exist in ordered pairs *PROG* and its interpretation or its compilation in some thing, some kind of M-individual, biological or not. Because to talk about running a program is utter fatuity unless you know the computer and the compiler and surrounding conditions for application (Lars Lofgren at the Baden-Baden meeting and his comments in my Festschrift-edited by Glanville, 1993).

Given these conditions a *PROC* is applicable and if applied yields a product. There is a process product/ complementarity. That is, there is no such thing as a product without a process to create it and no such thing as a process that creates no product. Let that product be written as follows $AP(CON_Z(T)) => D_Z(T)$ (which is a description or Spencer Brown distinction of, say, the characteristic behaviour of the differ-entailed growth phase of

a mushroom). This recursion gives us the nature of $CON_Z(T)$. Now T, I admit, is undefined, except that it may be regarded as a locus or target of a conversation between participants A and *B* which are as yet undefined. We shall, however, proceed to define them. It is evident that one may image, as one possible representation, a *PROC* as a directed line which if it exists eats its own tail, hence becoming a directed circle (directed either clock-wise or anticlockwise). It has hermeneutic or coherence truth, namely, a progressive refinement of meaning (Taylor, Rescher, von Wright and others).

It is the case that every *CON* contains an infinite number of refinements called *PROC* (with their indexes, subscripts or superscripts differing-either, both or multiple-which can become obscure-where appropriate, the limitations are typographical only) no doubt, but any of which (singly) or all (together) are capable of application. The application should be more carefully indicated to read *'PROC'* or *'CON'* (because *PROC* is a *CON),* produces amongst other things, $D_Z(T)$. In particular, it also pro-duces, since distinctions can be taken to 'repel' each other by virtue of being distinct, either it or any other application in the mental repertoire, an operator, $CON_Z*,$ acting upon a domain of concepts and of the type 'concept' having the effect of producing and, incidentally, reproducing the concepts. Thus the system is both organizationally closed and informationally open.

But what is the scope of this miraculous operator $CON_Z*?$ Its scope is what I have come to call a P-individual. Hence A and *B* are defined where its domain is some other concept or concepts, its scope is the entire domain of concepts under consideration.

The circularity induced when a *PROC* eats its own tail gives rise to a product, which may be represented as a cylinder surrounding it and is a torus of genus 1. However, there is a restriction that CONs are produced and incidentally reproduced in order that they be stable, not only exist transiently. Hence it follows that there must be more than one; in fact, to make it simple and easy to expound there must be three of them at least. Since all the distinctions are pushing each other apart towards infinity (they 'repel' each other), what holds them together? If we have chosen clockwise as the direction for our concept, CON, then an anticlockwise flux encloses them and holds them together as a stable concept and moreover it produces a boundary or distinction around it. That is the name we give to the concept also justifying our assumption about the infinite number of procedures or refinements within any concept.

In addition to those circular clockwise or anticlockwise motions there is an orthogonal force directed outwards repelling each from each other so that we must have, in order to form a stable concept, a contrary force-the conservation of parity, in fact, surrounding the whole lot. Further, it is possible to link concepts together under certain conditions which have been specified in detail in many other papers. The requirement is, of course, that in linking them together one can envisage an operator acting orthogonally, with respect to the circular clock-wise or anticlockwise operators, which penetrate the boundaries that are created as products and unfoldments on the mesh or the nexus of concepts, i.e. the mental repertoire of z, where z = A or B (as before), in such a manner that it forms a heterarchical or even hierarchical structure. As it happens, one can extract (by order preserving union) and coalesce the unfoldments which look like trees or quasi-trees. This is thought or many thoughts, some of which may be plans. Unique lines of thought are delineated by following one tree and noting, amongst other things, that percepts being concepts is a special case where the application of a concept traverses the environment. The domain of a percept is a loop in the environment which also determines the order in which thought of actions may be executed.

Further, the domain of operation of the concept is one or all of the remaining concepts. The domain of some concepts, however, is qualified in quality and directionality. I shall call this a prepositional operator appended to those concepts which are responsible for differing sensory modalities and their directionalities.

In order to formalize these concepts we adjoin a so-called prepositional operator, q. This overcomes the difficulties such as, for example, you can't get to the airport until you have taken a taxi (when thought is realized as action). That is, for example, in everyday life, travel may be thought about in many ways, but in action it must be done as ordered: taxi, airport, aircraft, unless a flight is delayed in which case wait. The statements are conditional. More forcefully in the domain of geography we may think of left and right as we please, but we cannot simultaneously turn left and right. (Although in the domain of politics we often do!)

In this we must keep in mind the stability of the concepts (not merely their transient state) and the domain upon which $CONZ$ operates:

  (i) The domain of all concepts and percepts is the mental repertoire of a participant (or participants).
  (ii) The domain of $CON,*$ is the domain of all concepts existing. Its range is all the concepts that may or may not exist. Its domain is what it operates on. Notably, the literal transfer of tokens takes place in the

set theoretic [i.e. the $D_z(T)$] part of the concepts and it is possible, in fact usual, for the description D to include a listing of $PROG(T)$.

What is communicated in a conversation is, of course, this set theoretic part. You can speak very reasonably of *PROG* being the member of a set of *PROGs*, but you cannot speak of *PROC* as being a member of a set. It is a member of a collection, a category, perhaps, but not of a set. A set theoretic part may and usually does contain a listing of the program *PROG* and this may be communicated. Furthermore, it may be inscribed at an interface which I call an entailment mesh. This has been sadly maligned, simplified and idiotically reduced to the cruder notion I started with which I call an entailment structure.

(What I have continued to call an entailment mesh can be activated so that the entities residing in it become dynamic concepts. Perhaps not the concepts of you or I, but of someone or some living thing. Whereas in the original entailment structure these dynamic entities were represented by models or processes attached to the names, this is no longer the case. An entailment mesh is no longer a stupid nominal thing of topic networks or information maps or the like.)

Suppose *A,* one participant, has his or her meaning attached to a concept, T, of let us say, a dog and the other participant *B* has his or her meaning attached to a dog. And *A's* and *B's* meaning even though they ostend the 'same' thing must be entirely different. For example *A* considers an affectionately well-clipped poodle and *B* considers a ferocious quadruped like the Hound of the Baskervilles. This is the really fascinating and important part about conversations.

The main purpose of conversation is not communication about T, whatever that may be, even though T is the focus of the conversation. But about *A* and *B,* about A's view of *B,* about *B's* view of A, about getting to know each other, about their coalescences and their differences, and the society they form. That is why I was so particular about specifying a P-individual. The M-individual (which goes with it) may be any interpretative medium, human, animal, organizational, possibly mechanical, possibly even cosmological. However, it is expedient to notice that the M-individual in which a P-individual is incarnated should bear that index of the P-individual, namely z. If you like, the particular moiety of the interpretative medium, the *INTER,* assumes the name of the P-individual which is incarnated in it.

Let us restrict the term 'conversation' to interactions which have a beginning and an end. Though there are interruptions-a tele-phone call, an absence on a trip or whatever-the conversation continues as though it had not been broken off.

AXIOMS AND OTHER POSTULATES

(1) Let *PROG (T)* be an algorithm open to application if it is interpreted in some (any dynamic) medium to yield T.

(2) $PROC_Z (T) = <PROG (T),$ INTER$_Z>$ such that $AP(PROC_Z(T) => d_Z$ which is a member of or a subset of $D_Z(T)$

(3) Let us suppose for convenience that expressions of form
$(AP(CON_Z(T)) => D_Z(T)) = T_Z$ that is T_Z
$= <AP(CON_Z(T)), D(T) >$
Lacking the subscript z the process exists, if at all, in an interface.

(4) For $z = A$ or B $CON_A (T)$ and $CON_B (T)$ are such that
$T_A \neq T_B$ (amongst other things) in a particular $CON^*_Z,$ where '$\neq$' stands for 'is not equal to' .

(5) $AP (CON_Z(T)) => D_Z(T); D_Z(T)$ is a cylindrical carapace, the products of the motion.
Under AP, of $T_Z,$ in particular the form under AP of
$< AP(CON_Z(T)),); D_Z(T)>= T_Z$
is a convenient rewriting of the lengthy expression and is valid under the conservation of AP. It does for special values of the index z such as T_A and

T_B indicate a pair of participants and if they happen to be embodied in distinct parts or M-individuals of the interpretative medium, they are separate participants. (Notice both T_Z and the ensemble continually evolve; they are not static).

(6) We may sketch in the creative, productive and reproductive, processes (production and reproduction under AP). The productive and reproductive operators are of a clockwise or anti-clockwise form and 'eat their own tails' . Using the previously introduced notation a participant is defined as <P-individual, M-individual>; since the extent of the medium or fabric in which a P-individual is incarnated is indefinitely specified (it can be anything) we may leave it unindexed except for that portion of it *INTER,* in which the defining subscript is inherited from the P-individual therein incarnated or embodied.

(7) Note that *PROG (*T) or in particular cases *PROG$_i$ (T)* is in D_Z(T).

(8) i is not equal to *j.*

(9) => implies goes into (amongst other entities), notably for some productions in z's repertoire *CON*$_z$.*

(10) $CON*_z (T) = [PROC_z^i (T)]$ (which is parallel by token of '[and]').

(11) $CON_Z(T) = \{PROC_Z^j(T), [PROC_Z(T)]\}$ (which is concurrency, an essential feature of life).

The essence of this is captured by noting that this expression is not as trivial as it seems. It does not mean that the activity of *CON*z* is started and stopped while *AP (CON$_Z$ (T))* or any other *CON* is started and stopped. There is no such shuttling. The processes are simultaneous. In fact they are concurrent and that is the form of life. This is z's consciousness *obtained between the* P-individuals constituting the participants, z, that is z's awareness. The P-individuals may reside in one medium such as one brain in which the conversation is between parts of the mind. On the other hand they may exist in different M-individuations in which case the conversation is between participants. *This is* A's *consciousness with* B.

(12) For at least some productions in the z-ensemble the term => (amongst other products) means produces *CON$_Z$*.*

(13) AP-individual, z = A, B, . . . , *is* specified as the scope of *CON** (That is a collection of concepts T_A, T_B, ... for z = A, B, . .   ) .

(14) Whereas it is possible to out-line the productive and reproductive character of concepts it is also possible to illustrate the transfer of set theoretic tokens, elements of or sub-sets of *D* through an interface, I.

(15) Due to the fact that a conversation is defined as having a start (s) and a finish (f) we have the following inequalities.

(16) (a) $T^sA \neq T^fB,$ (b) $T^sB \neq T^fB,$ (c) $T^sA \neq T^sB.$

(17) (a) $T^fA \neq T^sB,$ *(b)* $T^fA \neq T^sA,$ (c) $T^fA \neq T^sB.$

---

(18) $A \neq B$.

(19) If t_A and t_B are the duration times of A and *B* then $t_A \neq t_B$. This is so for all values of the participant, index z. Clearly because of the beginning and end certain events become evident with the transfer of set theoretic tokens (syntactically unique symbols) from A to *B.* The notion of understanding between A and *B* is a punctuation mark which must be specified. How is it specified? Clearly because of the beginning and end certain events give rise to what I call, in a technical sense, an understanding. Briefly, A asks *B 'What?'* questions by ostending some intellectual or concrete entity. *B* ostends T, that similar looking entity, intellectual or concrete, as it may be. Having asked that, there is an exchange of questions, this one being the basic *'What?'* question. The exchange of questions continues to 'How? ' . How do you make e.g. a dog? How do you use a dog? How do you do what ever you wish with a dog or whatever T stands for. These explanations are exchanged. Finally one asks 'Why?' . Why is it that you chose this derivation of dog from other concepts in your repertoire and perhaps concepts you invented. If this were firmed up it would complete the recursion. But firmed up it is not.

The durations for A and *B, . . . ,* differ since t_A and t_B are distinct and hence time is vectorial but commensurable. Commensurable in terms of duration, where a mapping is possible at each punctuation point of understanding on to Newtonian time.

Clearly it is possible to approximate, because of the beginning and end of certain events, by understandings, where it becomes evident that transfer of tokens from A to *B is* set theoretic only. But recall that $PROG_i (T)$ is usually a member of $D_Z(T)$ from $AP(PROC_Z (T)) => D_Z$ is usually a member of $D_Z(T)$.

(20) By process-product complementarity each circular process gives a distinction as a product. Hence the snapshot (kinematic image) is that of a many-holed torus of genus 1 to count-able infinity (for each hole). Many onion-like layers are distributed, alternately marked by their circular generating processes as being clock-wise or anticlockwise 'orientation' (that is of their 'spins ').

(21) Due to the repulsions produced by the clockwise and anticlockwise motions of mentation and coalescence to form conceptual clusters (that is, coherent clusters), there must be a process orthogonal to the clockwise or anticlockwise processes of mentation. This process, already noted, has been called unfoldment,and unfoldment is conserved throughout the ensemble. There are certain exceptions under certain types of anaesthesia and mental pathology.

AP (if you like, undifferentiated energy) is, however, conserved over the clockwise and anticlockwise processes of mentation and over the process of unfoldment which cuts across the distinctions of clockwise and anticlockwise mentation processes and thereby reveals them as distinctions or descriptions-a slightly extended use of   which we have adopted throughout. This applies, of course, to the clockwise and anticlockwise processes of production and reproduction as well as the application of concepts.

(22) If distinction is conserved it follows that the mesh of conceptual clusters is transformed into a tree-or heterarchy, perhaps. Further, that it is possible to extract certain branches of this tree as being trains of thought whereas the heterarchy or hierarchy are all possible thoughts that one might think, for

example those one might think in moments of great hazard as for example when mountaineering.

   Unfolding from T a particular free or arbitrary train of thought is dissected out.

(23) These thoughts may be in any direction. For example in this world (of geography) I think of left and right knowing full well that I cannot turn left and right simultaneously whereas in the world of politics I can entertain both left and right points of view at one and the same time. This is the freedom of thought.

   However not everything can be done in every world. To repeat the point in the world of geography, it is impossible to simultaneously turn left and right. Whereas in the world of politics it is perfectly natural to subscribe to left and right views. The dilemma is resolved by attaching a prepositional operator q which characterizes the domain of concepts. A concept with this attachment adjoined is called a percept. The application of a percept gives rise to action, but action appropriate to the universe and domain it describes and appropriate to the order of operations in such a domain.

(24) A conversation is an inter-action between at least two P-individuals who if embodied in different media are distinct participants.

(25) The truth value of a conversation is a metaphor or an allegory designating an analogy (difference A, *B;* similarity, generalization of coherent content of A and *B) .*

(26) To sum up the gist of the argument, there are clockwise and anti-clockwise processes of augmentation; the application of concepts in one circular direction and their productions and reproductions in the opposite direction. Call this mentation (AP being conserved). Each process gives rise to a distinction.

(27) There is (also conserved) *UN* or unfoldment for one or more concepts. *UN* cuts its way through the distinctions made by mentations and is more or less specific thought. UN is a category the-oretic unfoldment of one or more concepts in a direction orthogonal to the clockwise or anticlockwise motion previously discussed.

(28) Thought gives rise to action if a concept is qualified by q. If so *qualified* the concept is a percept.

(29) Interaction in a conversation is restricted essentially by an s (start) and f (finish) which admits a punctuation of symbolic set theoretic transfer between P-individuals.

(30) If these P-individuals are incarnated in the same M-individual then we have the dialectics of mind.

(31) If embedded in distinct M-individuals we have, in the usual sense, conversation between two participants.

(32) In each case the truth-existence-value of a conversation, or mental dialectic, is a metaphor or allegory designating the analogy which is the conversational act. With reference to clause (11) *awareness and*

> *consciousness are carriers of affective meaning, i.e. the real meaning: emotion.*

INTERACTION OF ACTORS

The interaction of actors is a matter that calls for far more fundamental assumptions. I shall sketch some of these only, the main intention being to compare and contrast conversation theory with interaction of actors theory.

(i) An actor is a participant enacting a role. This role may be defined (as in Eliot Jacques' work e.g. Jacques, 1964) or outlined as in Fenton Robb (Robb, 1980), or may emerge from a situation and the actions taking place. For example, in Robin-son's research (Robinson 1977) into the Brighton Rent Group (an orderly organization of squatters) where roles of 'public relations manager' and 'legal expert' emerged in order to maintain an organizationally closed and informationally open self-organized (and viable) system.

(ii) Once established a role may be played (often in different ways) by the same actor or different actors. Hence there is mutual actor and role interdependence which influences the evolution of the system.

(iii) Conversation is defined as having a beginning and an end and time is vectorial. The components of the vector are commensurable (in duration). On the other hand actor interaction time is vectorial with components that are incommensurable. In the general case there is no well-defined beginning and interaction goes on indefinitely. As a result the time vector has incommensurable components. Both the quantity and quality differ.

(iv) In both cases the generalization of distinctions and their resolution by analogy creation is a matter of conflict and conflict resolution. This could be represented by forms of competing and co-operating ('chaotic' or 'strange') attractors if it were possible to construct a respectable phase space. However, in view of the vectorial nature of time this is no simple matter.

(v) There is some similarity between the many holed tori and their onion-like layers of distinctions [clause (20) of the last section] and dynamic structures in the general interaction (of actors) theory; however in the general case a 'snapshot' is inadmissible [it is at most a useful approximation in clause (20)]; we are in a kinetic world and the tori and their skins are developing.

(vi) Interaction of actors has no specific beginning or end. It goes on forever. Since it does so it has very peculiar properties. Whereas a conversation may be mapped (due to a possibility of obtaining a vague kinematic, picture-frame image, of it, onto Newtonian time, precisely because it has a beginning, and an end), an interaction, in general, cannot be treated in this manner. Kinematics are inadequate to deal with life: we need kinetics. Even so as in the minimal case of a strict conversation we can construct the truth value, metaphor or analogy of A and B The A, B differences are generalizations about a coalescence of concepts on the part of A and B; their commonality and coherence is the similarity. The difference (reiterated) is the differentiation of A and B (their agreements to disagree, their incoherences). Truth value in this case meaning the coherence between all of the interacting actors.

It is essential to postulate vectorial times (where the components of the vector are incommensurate) and furthermore times which interact with each other in the manner of Louis Kauffman's knots and tangles (Kauffman,1995). This has been noted, for example, by Petri (1963) and by the editor, Glanville (1975, 1988). We see it in any airport. The times of the booking clerks, the captains of the craft, the baggage controllers and so on are all different times. Quite different, quite different in kind and quality. You cannot map them on to the simple co-ordination Newton devised. This, I believe, is well known but frequently hidden as not supporting the status quo.

A COMMENTARY

The form not the content of the theories (conversation theory and interaction of actors theory) returns to and is congruent with the forms of physical theories; such as wave particle duality (the set theoretic orthogonal unfoldment part of conversation theory is a radiation and its reception is the interpretation by the recipient of the descriptions so exchanged, and vice versa). The particle aspect is the recompilation by the listener of what a speaker is saying.

Theories of many universes one at least for each participant-one to participant A and one to participant B--are bridged by an analogy. As before this is *the truth value of any interaction; the metaphor for which is culture itself.*

A DISCUSSION

During the preparation of this paper I had the great advantage of a discussion with Graham Barnes and he asked me, amongst other things, what a conversation with Heinz von Foerster, himself, was like. I replied that it could be terribly formal, like the last few paragraphs.

'Is that all?' said Graham. 'Oh certainly not.' I replied. 'Well tell me what was so special in a conversation with Heinz?'
I pondered for a moment. 'You need a context to talk about a specialty of some kind. I am going to choose courage as the attribute concerned.' 'Well,' said Graham 'Go ahead'.

A little bit of background is needed. Heinz and Mai had three sons, of whom Johnny was the eldest. Johnny had just been killed, a few days past only, in a motorcycle accident while serving with the International Peace Corps. Heinz was grieved and although he had agreed to speak at and in a sense to co-chair an AGARD conference in Europe, I didn't for a moment expect that he would make it. But in fact he did, even though
distressed. We met with a kindly reception in France and in many other places, with what Heinz called our 'circus' consisting of eminent people, professors and locally a lot of students, research associates and assistants of professors of great merit. (In a sense I belonged to their generation.) Only at one point was any offence created and that was by a bureaucrat in a certain town in Germany, and it was because they entertained us as a prestigious group and part of NATO so badly they had the effrontery to invite us to dinner in a railway waiting room and self-service buffet. At the end of this everyone was obviously upset. I asked Heinz if as a special favour he would give the vote of thanks. He did so in perfect German. I have never heard a speech so humorous, so sympathetic and so damning of the bureaucrats. We walked out and several of the graduate students, assistants and so on followed us because they had become very fond of Heinz. I said to him 'Shall we go as usual to a restaurant and ask them to a glass of wine?' He said. 'Oh, yes I suppose so but I really feel in no mood for jollification.' I was ashamed but I sort of lead him on and we went to a small place and I had a word with one of the local participants in the conference and I said 'Well let us go as soon as possible,' relating why. Namely Heinz' recent bereavement. Yet Heinz came, chatted to the students, satisfied them. He got to know them because there is no conversation with Heinz where you did not get to know more about Heinz than you did about the subject, formal or otherwise, being discussed. And true to his word my colleague amongst the participants fairly soon terminated the event. Heinz and I came out distressed but happy.
We walked back to our Hotel which the bureaucrats had selected. A very comfortable one. I think it was only the local participants they didn't like. I became increasingly anxious in case I had offended Heinz and wondered whether to tell him the truth or whether it would be more polite not to do so. The truth is, as I outed it in the hotel once we were inside the foyer, 'You have just reincarnated Johnny, Johnny von Foerster.' And I alluded, of course, to all those graduate students, research assistants and so on who participated and were so glad to have their own views understood and authorized.

'Did Heinz reply to that?' said Graham.

'He hugged me as a father might do his son. As my father would have done to me in a moment of danger or distress. That hug encompassed all the students, professors and so on.'
'What did *you* say?' asked Graham.

'I burst into tears. I was *so* glad to see a demonstration of courage, enough to revitalise the world.'

ACKNOWLEDGEMENT

REFERENCES

Barnes, G. (1996). *Systems Research.*

von Foerster, H. (1981). *Observing Systems,* Varela, Francisco (ed.) InterSystems, Seaside, CA.

von Foerster, H. (1995). *Cybernetics of Cybernetics,* 2nd edn, Future Systems, Minneapolis, MN.

von Foerster, H., and Pask, G. (1960) A predictive evolutionary model, *Cybernetica, 4,* 258-300, 1-55. Glanville, R. (1975). A cybernetic development of theories of epistemology and observation, with reference to space and time as seen in architecture, unpublished PhD Thesis, Brunel University, Depart-ment of Cybernetics.

Glanville, R. (1976). What is memory that it can remember what it is? in Trappl, R., and

Pask, G. (eds). *Recent Progress in Cybernetics and Systems Research,* Hemisphere, Washington, DC, Vol. 2.

Glanville, R. (1988). *Objekte,* Merve, Berlin.

Glanville, R. (ed.) (1993), Festchrift for Gordon Pask, *Systems Research, 10, (3).*

Goguen, J. (1976). Objects *International Journal of General Systems 1,* 237.

Jaques, E. (1964). *Time Span Handbook,* Heineman, London.

Kauffman, L. (1987). Self-reference and recursive forms, *Journal of Social and Biological Structures, 10,* 53-72.

Kauffman, L. (1995). Knot set theory, American Cybernetics Society Conference, Chicago.

Pask, G. (1980). The importance of being magic, *Journal of the American Society for Cybernetics,* special edition.

Petri, C.-A. (1963). M.LT. thesis on Communicating automata. Also in Bateson, C. (ed) *Our Own Metaphor* and Annatole Holt's comments on C.-A. Petri s outstanding work at Gregory Bateson's Conference at Borg Wartgenstein.

Rescher, N. (1973). *Coherence Theory of Truth,* Oxford University Press, Oxford.

Robb, F. (1980). The dynamics of opinion change from a systems theoretical viewpoint, unpublished PhD Thesis, Brunel University, Department of Cybernetics.

Robinson, M. (1977). Human social groups: a cyber-netic account of stability and instability, unpub-lished PhD thesis, Brunel University, Department of Cybernetics.

Schrodinger, E. (1947). *What is Life?,* Macmillan, New York.

Taylor, C. (1967). *The Explanation of Behaviour,* Rout-ledge, Kegan and Paul, London.

Taylor, C. (1973). Interpretation of the sciences of man, *Review Metaphysics* 25, 3-51.

Wells, O. (1965-1957). Artorga, *Journal for Research into Artificial Organisms.*

von Wright, G. (1963). *Norm and Action,* Routledge, Kegan and Paul, London.

INDEX