

I. New Order from Old

**New Order from Old:  
The Rise of Second-Order Cybernetics  
and  
Implications for Machine Intelligence**

A Play in 25 Turns

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1. New Order from Old.....	1
2. Actor's Note.....	2
3. Audience and Conventions.....	2
4. Introductions.....	2
5. Prologue.....	3
6. Investments in Notions I: Reality, Knowledge and Inside/Outside.....	4
7. Investments in Notions II: Subjectivity, Agreement and Experience.....	6
8. "When is Cybernetics?".....	6
9. "When is Cybernetics?": An Historical Sweep from the Present, back to its Origins ...	8
10. The Start of New Cybernetics: At its Origins, in the Parable of the Thermostat and the Concept of "Control".....	12
11. The Rise of Second-Order Cybernetics: A Shift from Absolute (external) to Relative (internal), as in from "What" to "When".....	14
12. Validated Subjectivity: Scientific Discourse as Recursive Consensus.....	17
13. The Shift of Value and the Rise of Ethics: Truth into Agreement.....	18
14. Recapitulation.....	20
15. Closure and the Closedness of the Nervous System Input/Output and Domains of Interaction.....	20
16. Representation: A World Outside vs A World Among.....	27
17. Implementation: A World Inside vs. A World Through.....	30
18. Embodiments of Mind: The Micro-Structure of Concepts.....	35
19. Interaction: The Architecture of Linguaging.....	47
20. Selves as Observers.....	54
21. Machine Conversants.....	56
22. The Dance of Agreement.....	58
23. The Technology of Intelligence: Summary and Comparison to present-day Artificial Intelligence.....	60
24. The Intelligence of Technology: Implications for corporate social change, networks and machine intelligence.....	62
25. Epilogue: Machine Narcissus.....	63

The original manuscript was written in 1988 and made available on the Web in 2002.  
Internal dates and references have not been updated.

## 2. Actor's Note

The relationships between structure and function, form and content, process and product are never more poignant than in those human activities called the arts.

Distinctions between art and non-art (just to generalize for a moment) are sometimes subtle and (always?) arbitrary; however it is agreed that certain concepts (alias experiences) cannot be conveyed except in art.

Invoking this at the moment of setting down the concepts that follow, and because what follows began as live lecture/performance applied to a participating audience, I found it necessary to reach for an alternative to the conventional form of written prose piece. Even a 'first-person', as-if-spoken-text written verbatim, would not serve.

The reader (alias audience) is invited to indulge (and indulge in) my use of this shift from conventional form of a written monograph. Acceptance of this shift, should it come, shall not be through the tolerant reading of the text but the (sometimes imperceptible) adoption, and therefore reconstruction by the reader, of the relationships among concepts presented here.

These two elements (the shift of form from prose to performance, and the shift of information from conveyance to construction) manifest the very essence of second-order cybernetics.

## 3. Audience and Conventions

The primary audience for this presentation is not presumed to have a background in cybernetics, so topics central to the themes are developed from basic notions. However, just as is true for any presentation, some aspects of the work are intended for those who do understand the field and its history and conventions. All possible attention has been given to the manner in which concepts unfold, perhaps suspend and are later revealed or re-entered.

In terms of the written presentation, many conventions of stage scripts have been adopted. Text in italics, when found in the course of the spoken script in *{curly brackets}*, contain stage directions, suggesting to the actors the manner in which the lines might be spoken. Non-bracketed words that appear in italics *in the course of the spoken text* are spoken *emphatically*.

At the same time, all possible advantage has been taken to provide the full support common to journal papers, such as footnotes and bibliography. [Square brackets] contain editorial notations and remarks common to written works, and, similarly to italic text, are not in the same domain as the performance itself. References are included in <angle brackets> in this version, as are <updates to the original 1988 manuscript>. All such conventions of written works are used as appropriate, but are not spoken in the course of the performance.

## 4. Introductions

*{A spare auditorium with stage lights projecting on a podium. Overhead projector and screen are also in evidence, but no other details. The introductions begin.}*

Introducer: It is a pleasure to introduce Dr Paul Pangaro, our next speaker today. Paul received his undergraduate degree at MIT in Humanities, really Drama he tells me, with a minor in

Computer Science. All the while he was working too in computer graphics and film, and user interface research. While at MIT he met, and then traveled to England to study and work with, Dr Gordon Pask, who became his doctoral thesis advisor at Brunel University. Paul now directs research and development contracts from the Washington DC office of PANGARO Incorporated, while his associate in PANGARO Limited in London continues the work for the Ministry of Defense started in 1981. Paul is also Chairman and CEO of SOLITON, Inc., a new venture in Cambridge, Massachusetts, whose sole purpose is to commercialize the application of Pask's Conversation Theory to computer-based training.

*{Pangaro enters from the wings, dressed in light blue linen jacket, iridescent silk tie, and black pleated trousers. During the performance his style varies from formal to personal; the timbre and tempo of his voice changes frequently. The hint of humor, or the edge of an emotional tone is always close by.}*

Pangaro: To begin, I would like to introduce my own introduction, which Dr Gordon Pask has kindly agreed to perform for me. I have asked Gordon to do this for me because of his understanding of the form I wish to present, and especially because of his first-hand experience in the music halls of Great Britain.

*{Pask moves to the podium. He is dressed, as always, in Edwardian double-breasted suit, proper bow tie, and knee-length cape with umbrella. During his introduction he makes sweeping gestures with his arms and hands and umbrella, which cause the cape to sway. He speaks his introduction in the loud, projecting voice of a music hall compere one who announces the sequence of acts called turns, and who hovers over proceedings. He fills the hall with sweeps of sound, highs and lows, happy and serious, and all in an English accent.}*

Pask: Thank you very much; laaaaay-deeeees and gentlemaaaan we present for you today an act often seen around the provinces but never quite the same, the one, his only, Paul Pan Garooooooh.

Pangaro *{returning to the podium}*: Thank you very much, Gordon, and especially for wearing the cape.

Pask: *{calling as he takes his seat in the audience}* Naturally.

## 5. Prologue

Pangaro: My talk today is about talking. It uses my self as the medium of performance. It's also about listening. That's where you, the audience, comes in. And I'll be listening too. And maybe you'll be talking, if only later.

I ask you therefore to take performance as a metaphor for much of what I wish to convey to you today. Some of the full richness of this is:

- how, as the performer, I can do it or be it as well as speak about doing it, requiring a self-reflection in presentation as well as in preparation
- how the experience of many (the audience) is expressed through one (the performer)
- how there is a loop through the performer to the audience and back to the performer
- where the emergence of self and other is explicit, though we each take both roles at various times

- where the designated roles of performer and audience are not fixed, because, after all, I am also the audience of your reactions to me.

Because of the physical nature of a performance it is my task as performer, too, to convey a story, a narrative that includes exposition and development (the conventional 'beginning and middle') with a sweep (to 'the end'), which is not death but fulfillment, completeness but not finish; that is really a closure, upon which recursion begins.

*{Pangaro pauses to consider relating the performance metaphor and its elements to concepts of complementarity, duality, and conservation, so important in any comprehensive scientific theory, in order to show a more formal side of cybernetics; this was the side taught him by Pask. But he realizes that there will not be time.}*

In summary, as the TV pastor Reverend Ike would say on being questioned about the propriety of a preacher spending his parishioner's donations on dozens of Rolls Royce automobiles, 'My congregation experiences the bounty of riches through me.' So too I wish to offer to you the an experience, one journey, through this field called cybernetics, through my talk today. But I'm not here to preach, and nor would Reverend Ike: I only wish to offer a few stories.

## 6. Investments in Notions I: Reality, Knowledge and Inside/Outside

Pangaro *{placing a quotation on the overhead projector}*: I would like at this beginning to present my first statement, to discuss briefly the ideals it contains, and then, in detail, to explain how each of these apparently irrefutable ideals can be usefully replaced.

*{The quotation on the overhead is 'Statement I. To hope that a machine can possess intelligence is to invest in notions of reality, knowledge, and inside/outside.'}*

'Reality' is something we tend to take for granted: namely, that 'it exists.' The world is real, and present, absolutely it is. Objects in the world are recognized, generalized, named. They – see I've made them more real by calling them "they" – they exist on their own. And their existence continues somehow whether or not we see them, or think of them, or continue to test that they are there. These presumptions are basic and our language reflects them all the time --- *really it does.*

We often presume too that the world as it exists can be well and perhaps even fully known by us, and that we have access to it by our senses and the measuring instruments that we build.

So too do we believe that this world, independent of our existence, is objective (rather than subjective) because it is outside of us and continues on its own.

*{He pauses speaking and reaches for a glass of water.}*

Pangaro *{almost as an aside}*: This is a prop, don't think I'm just taking a drink of water. *{He drinks and places the glass down again.}*

'Knowledge' is another notion that comes from a world of objects: once we form a constant view of some *relationship*, rather than 'object', in the world (say that of 'tension' or 'energy' or 'freedom') we name it and it too takes on a semblance of the real. We write it down in words, embellish it with related ideas and form a complex structure of concepts that appear to stand

on their own. That is, we give concepts 'objecthood' and consider them to exist independently of our own participation in them. Reinforced by the fact that others appear to have the 'same' concept, we invest in the idea that the knowledge is independent and outside of our bodies – this investment seems to be the basis on which we understand each other. One of the many aspects lost is that of the original concept, the one that expressed a relationship and was a process of comparison. It has become a static inscription, a dead carapace *{both phrases from Pask}*.

You will recognize that the field called artificial intelligence (AI) invests so strongly in this notion of knowledge that it spends nearly all its time searching for the best means to represent knowledge in a data structure, inside the computer.

Necessary to support the concepts of reality and knowledge is the notion of 'inside and outside.' Informally, we say that there are things going on inside our heads and other things going on outside, in the world. We usually emphasize what is happening 'inside' the brain, and minimize the role that the world plays in its contribution to 'internal' processes. And because the world is considered to consist of real objects, we think that our job is to make representations in the brain, one for one, of the objects 'outside' in the world.

So, I say that each of the concepts of reality, knowledge and inside/outside mutually support each other.

There are many problems that come from this, I think, and *{very genuinely}* there is an argument that these include the ills of a post-industrial planet. In a much narrower context, the failures of AI might also be blamed on these common views.

There is an allegory that I would like to tell, to begin a process of revision of these notions, that I call the 'pencil allegory.' Imagine that I ask you to multiply two numbers 'in your head': say 4 and 6. You give the correct answer of 24, easily and quickly. It appears, then, that the 'intelligence' that performed this calculation really is 'in your head.' Next I ask you to multiply two, much-longer numbers, say 28736487236487 times 12763812. Ah, you say, now you need pencil and paper, which, upon presentation, allows you to perform the calculation. I immediately ask the question, Where does this calculation take place? Well, clearly it is distributed somehow between 'your head' or 'your brain' (or some metaphor like that, for these are only cultural metaphors) and the pencil and paper. Right, say I, so we might say (informally if you wish, or formally if it does not make you too uncomfortable) that 'the brain' that does the calculation is made up of at least you and the pencil. But, you hasten to add, 'most of it is in my head.' What do you mean, I reply: What difference is there if I take away your pencil or take away your head? In either case the calculation cannot be done.

Of course this could make you unhappy, you may consider it an insult: You say that the contribution of 'your head' is more important than that of the pencil. But where did you get the pencil? From an industrial society that can produce it, and give you access to it, as well as give value to the entire relationship of pencil, writing, and arithmetic to teach you how to use it. All these things provide you with what you call 'your capability' – and all these things come from what even you call 'the outside.'

Now, if you take away any of these things (industrial production of pencils, distribution and marketing, the education system that taught you how to multiply), the calculation cannot be done. Applying the same test about what is needed for the calculation, as above, we must say that all these components make up 'the brain' that does the calculation. And in this sense, 'cognitively speaking', there is no outside and inside.

## 7. Investments in Notions II: Subjectivity, Agreement and Experience

Pangaro: I propose the following alternative notions, in the form of the dual of the previous statement:

*{He replaces the overhead slide with text that adds a second statement to the first, as follows:*

*'Statement I. To hope that a machine can possess intelligence is to invest in notions of reality, knowledge, and inside/outside.*

*'Statement II. To prefer that intelligence is an attribute of a conversation is to invest in notions of subjectivity, agreement and experience.'*

Pangaro: *{Reaching for the water glass again:}* This is a prop, don't think I'm taking a drink of water. *{He sips the glass again, replaces it..}* My main proposal today is that, what informs this shift, from Statement I to Statement II, is a field called Cybernetics, and specifically second-order Cybernetics. In giving you a sense of understanding of cybernetics let me begin by saying that, contrary to popular belief, it is not freezing dead people.

## 8. "When is Cybernetics?"

Pangaro: So often have I been asked the question, 'What is Cybernetics?' and there was a time when I used to try to answer it. Since it is a confused question, trying to answer it was probably a mistake, and here is why.

Let me show this by first asking the question, 'What is a rock?' The question as phrased and by its nature implies that rocks exist and that they can be known and defined. This existence stands on its own to such an extent that an answer can be given, 'A rock is --- dot dot dot'; and this description is given as independent of time, context, and observer. The act of providing an answer is to buy into the position that there is a reality that can be expressed in this independence.

Of course the reality is in one sense in the description, not any 'object itself.' We do invest in the description as a thing, an 'objectification' that exists on its own, which is what we call knowledge. The contribution of personal experience is lost or elided. What is left is the dead description, devoid of a maker and the context and purpose in which it is made.

All of the above observations show how the question 'What is ... ?' itself contributes to, and is itself a paradigm (in the true meaning of that word) that creates the investment in notions of reality, knowledge, inside/outside that we wish to inform. Hence, asking that question about these notions is tautologous and cannot admit any insight. The complementarity of question and answer is a mutual constraint.

I owe my insight into the question, 'What is ... ?' to Herbert Brün, performer, composer and musician. He substitutes the question 'When is ... ?' and by doing so captures the essence of the cybernetic act: taking an apparent absolute and providing necessities for taking it as a relative. In Herbert's words [added punctuation in brackets]:

*'The by far most important, most significant context, overriding in power every other[,] even ever[-]so-blattantly[-]perceivable context, the context decisive in the beginning and in the end, in the speaker and in the receiver, the context which gives its meaning to a*

statement, the context in which a statement is most undebatably made, is that context which we call "The person who makes the statement." And let the period after the quotation mark be legal. For to be quoted is not my statement but "The person who makes the statement" and the context he is, not I make.' <Brün, Herbert: *my words and where i want them*, princeton editions, London, 1986, 313>

The shift of 'What' to 'When' makes the relativity of knowing quite explicit in the description. The relativity exists as a function of the (ever-different) contexts: time is one such context, the 'I' is another (ever-present) one, purpose is still another. Perhaps these are alternate, or at least overlapping, names for the same phenomenon.

Notice clearly that we are speaking here of a Heisenberg principle. Not the trivial one often quoted (that all experiments are perturbed by the experimenter) but the significant one where some contexts of observing distort or eliminate others by their nature. If I seek a particle, I cannot see the features of a wave, and vice versa. The complementarity of each of these descriptive forms precludes the other; the observation itself determines the scope of the observation --- and hence any 'What' is only convenience or delusion. <For an exceptional discussion of the role of the Heisenberg principle in cybernetics, see Lofgren, Lars: "*Towards XXX System: From Computation to the Phenomenon of Language*", needs publication ref>.

I had become fond of phrasing this (before Herbert's revision) as: cybernetics is the act of making the relativity of observation explicit in any description. I once proudly told Heinz von Foerster that I had recently realized this way of expressing it. (We were sitting in the upper story of the house that he and his wife Mai built after he retired from the University of Illinois.) His eyes flashed characteristically as he responded, *{Pangaro imitates von Foerster's accent}* 'Pauhhlllllll, yeas, thees iss fan-taaaaass-tik, mahrveloose, yeas off coourse ...' Then the following week I read in a paper that, 'It is Heinz's motto not to forget the injunction to put the observer into the description.' <Varela, Francisco: "The many faces of circularity", *Journal of Institudes de la Famille et des System Humains*, Bruxelles, M Elkaim (Ed.)> I was struck immediately by a bifurcation; with how I had in one sense 'invented' him but then of course I was disappointed that I had not been 'original.' But this was followed by elation, for indeed I had invented him. What better event to demonstrate the interpenetration of our mental lives. The structure of circularity-to-recursion-to-reinvention is how the field of cybernetics explains this event with Heinz. Similarly it supports the notion that, cognitively speaking, there is no inside and outside.

My reaction of disappointment is what is sympathetically called human; I prefer to think of it as cultural. So much is invested nowadays in how something is *{huffy}* my idea, not your idea; how 'I invented it'; the 'not invented here syndrome', et cetera. Anyone else's participation in the formulation of an idea is to be denied or minimized. In fact there are even products on the market today that emphasize that intention.

*{He holds up a small, orange canister of roll-on deodorant. The label clearly reads "My Idea".}*

Pangaro: You see, I just purchased this in the local book store on this campus just a short walk away: 'My Idea' anti-participant spray. And here is another popular brand that you all have heard of.

*{He holds up another deodorant canister. It reads "Secret."}*

Pangaro: You use this when you want to keep ideas to your self. And here is a milder version, for when you want to make it difficult but not impossible for others to be creative. *{He holds up a deodorant that reads 'Arid.'}* This one also comes in different strengths, including 'extra dry.' So

if you are afraid of having your ideas taken, you just use these; the tricky part is that you have to roll them on other people, not on yourself.

## 9. "When is Cybernetics?": An Historical Sweep from the Present, back to its Origins

Pangaro: So now we will fool with the semantics another little bit and provide a sweep of history while we interpret the question of 'When is ...' in purely the temporal sense: in historical time. When was cybernetics started? done? done-in? I offer not a complete history but a near-sighted, 'North American' view to give at least a taste of a field that is so misunderstood it is essentially unknown to academic and intellectual circles in its richness, its diversity and its expressive power.

I have mentioned Herbert Brün, who has produced a body of work that includes musical compositions, writing, and daily 'performance' in teaching and lecturing that has influenced generations of students of music, theatre, and politics. His quotation, already given, is clearly in the realm of cybernetics and (as we shall see) second-order cybernetics. His influence comes centrally from his command of language and his awareness of its role in social interaction, politics, freedom. {*He reads some of Brün's writings..*}

'Language is not to be understood but to make understood that which is neither language nor understood.' <Brün: *Op. Cit.*, #16>

'Instead of attacking people for their views, attack, rather, their views for them.'  
<Brün: *Op. Cit.*, #53>

Typical of much of cybernetics, what you expect to hear is often confounded by what you at first think is the opposite of what makes sense; but you then realize that what you previously thought makes no sense.

{*Reading again from Brün.*}

'I consider words innocent until proven guilty. Once they are proven guilty, however, I consider their meaning to be irredeemable. Thus words form the limits of personal freedom. While I may be free to express my thoughts in a free society, the words at my disposal may not be free at all. Ignorance of this fact is what turns the thoughts of free people into the thoughts of slaves.' <Brün: *Op. Cit.*, #2>

Herbert was Professor of Music Composition at the University of Illinois at Urbana/Champaign. This place is itself significant in the history of the field of cybernetics because of the existence of the Biological Computer Laboratory (BCL) there. Herbert would still have produced his work and been so strong a force at the University, but without the existence of the BCL and its most influential director at that university he may not have so easily been allied with cybernetics as a field, and felt the synergy that has resulted.

The BCL --- note it's "biological computer" not "biological computing" --- was directed for many years by Heinz von Foerster. Heinz's own work has been prodigious and original. Some of his papers <An excellent collection of von Foerster's own papers is that of von Foerster, Heinz: *Observing Systems*, Intersystems Publications, Seaside, California, 1981. The concepts presented here are best represented there. More readily available is von Foerster, Heinz: *Understanding Understanding*, Springer Verlag, 2002> from the mid-1970s ('Computation in Neural Nets', 'Time and Memory' and 'Memory without Record') managed to relate fundamental requirements

of any theoretical and practical approach, to the problems of neural nets, and at a time when perceptrons were being left behind for political reasons. <For an attempted revision of the history of the perceptron, see Minsky, Marvin L. and Papert, Seymour A.: Perceptrons, Expanded Edition pp. 247-280. This version specifically has added material on their version of history. Verbatim quotations of Minsky in the "Profiles" column of the New York Magazine 14 December 1981, are also illuminating> For example, Heinz argues how memory must be computationally- rather than retrieval-based, otherwise it could not work within the constraints of the biology. Concepts are therefore processes all, and they are processes that never stop running for the life of the organism. They may and do evolve but they do not cease; otherwise so does the organism in its self-hood, its identity. In considering the ontogenesis <Ontogenesis, the origin and development of the individual> of the organism, each formulated concept runs, produces a result, and that result becomes the starting place for the same concept running again. The recursive process converges over time to a stable concept, and that stability is what we call memory. It was Heinz who first considered these issues in this way and proposed that Eigen functions and Eigen values be the model for them <Personal conversation with von Foerster, 1997>.

Eigen functions are in some ways like the functions you remember from school. One simple type is written in the general form as  $y = f(x)$ . The function is called 'f' in this case; it operates on some variable called 'x', producing a value called 'y'. Eigen functions can have this form, but they have additional features. They have their result (the 'y') fed back into the equation as a new value for the argument (the 'x'); this process continues indefinitely. This would be represented thus:

$$y_1 = f(x)$$

$$y_2 = f(y_1) \quad y_3 = f(y_2) \quad y_4 = f(y_3) \dots$$

or

$$Y = f(f(f\dots(x)))$$

For some functions 'f', the value of 'y' converges. Some examples:

$$y = (x/2 + 1) \text{ ---> } 2 \text{ or}$$

$$y = \text{square-root}(x) \text{ ---> } 1$$

When the process repeats and the value of 'y' converges or stabilizes, the analogy to concepts is complete: the more you experience the world (recursion over repeated execution of the function, i.e., your experiences), the more you stabilize your mental repertoire into persistent ideas (the value that is computed converges and stabilizes). Of course the value in mental events is not so simple as a single number; nor is the function itself a simple arithmetic transform of a single variable. This complexity can be reflected in more complex equations. Heinz's insight was that Eigen values and Eigen functions have the right characteristics to be a useful exposition of cognitive activity: that 'y' is a valid model for concepts, and 'f' is a model for the process of cognition. (In fact for cognitive events, Pask will later say, what we call the values and what we call the operations is arbitrary, they are merely complementary pairs. <Pask, Gordon: "Developments in Conversation Theory, Part I", *International Journal of Man-Machine Studies*, Volume 13, 1980>) Nowadays the popular concepts of 'attractors' in chaos theory expresses a number of applications of these types of behaviors in non-linear systems; but still their application to mentation is usually missed, even after 25 years of being available.

Heinz published over 200 papers under his name; his BCL produced a total of some 300 papers that were made available from a single source on micro-fiche. <Wilson, Kenneth (Ed.): *The Collected Works of the Biological Computer Laboratory*, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, published by the Illinois Blueprint Corporation, Peoria, Illinois> The production of the volume 'Cybernetics of Cybernetics' <*Cybernetics of Cybernetics, or the Control of Control and the Communication of Communication*, Biological Computer Laboratory, University of Illinois (Urbana/Champaign), 1974. More recently available from Future Systems Books, <http://www.spinelessbooks.com/cybernetics/>>, the title itself an anthem of second-order, stands as a strong collection on the subject, in both form and content.

Heinz's contributions above and beyond the simplified examples and statistics given above were that he brought together so many individuals at the BCL, individuals who were or have become major forces in the field. A short list must include Humberto Maturana, Warren McCulloch, Gordon Pask, Ross Ashby.

Humberto Maturana (affectionately known as Chicho), with Francisco Varela and Ricardo Uribe, has revolutionized his field to the degree that it requires a revised name: 'New Biology.' This 'New Biology' is not the New Biology of holistic healing and California thinking; it is a revision of the study of living systems. Concepts such as autopoiesis, which I will describe later, have come from this. Ironically Chicho is just now finding his influence greatest through a secondary source, the book by Flores and Winograd <Winograd, Terry, and Flores, Fernando: *Understanding Computers and Cognition* Ablex Publishing Corporation, Norwood, New Jersey, 1986>. Although it presents only a first gloss on Chicho's work, the book has begun to galvanize workers in AI into realizing that there are alternative views of the nature of language and computation, and that some goals might not be achievable within certain definitions of intelligence and knowledge. As this is a theme close to my purpose here, we will return to these points and to Chicho in detail later.

Warren McCulloch was a neurophysiologist who was recognized as a genius and great source of inspiration and influence to a generation of giants: Minsky, Papert, Lettvin, Pask all, without exaggeration, revere him and have said so in print. So many stories I have heard about this man, that I never met (I arrived at MIT in the month he passed away), about his tall, mystical genius. His widow, Rook, also extra-ordinary, lives still on their farm in Connecticut, constantly visited by travelers from all over the world who come to visit her and to talk of Warren and his work. <Rook passed away in the 1990s.>

McCulloch spent a lifetime seeking a mapping from physiology to logic, but not a functional, 'this neuron does this, that neuron represents that' approach. The quest for a functional mapping of areas of the brain to specific concepts in the mental repertoire can be debunked by the story of the 'mother neuron.' Assume that science manages to determine which specific neuron holds the meaning of 'mother' for a specific individual, and assume further that this single neuron can be removed from the brain surgically, perfectly, and that the patient is now awake and doing fine after the surgery. You ask the patient, 'Tell me about your mother' and the patient replies with a blank stare and a large, "Huh?" So far, so good. Now, the story goes, you ask the patient, 'Tell me about your father' --- what happens now? Are you to expect that the idea of 'father' is also gone --- how could that be, because the premise was that you removed a tiny portion of the brain, isolated to the 'mother' concept only? Or, are you to expect that 'father', a concept that exists in close and inextricable relationship to 'mother', is still present? What if you asked the patient, 'Who is home when you came home from school as a child? With whom do you associate the smell of pies baking in the kitchen?' I can still hear this story being told by Jerry Lettvin, a student of McCulloch, to illustrate the point, but there I get ahead of myself, so to speak, for we will come back to Jerry in a moment.

And he was a (perhaps unwitting) catalyst in the whole AI movement. <Letvvin, Jerome Y.: 'Warren McCulloch and the Origins of AI, printed in *Cybernetic*, Vol I No I (Summer-Fall 1985), published by the American Society for Cybernetics, pp 5-15. See also Letvvin: "Forward" to new edition of *Embodiments of Mind*, MIT Press, Cambridge, Massachusetts, 1988. > He and Walter Pitts developed a 'logical calculus' that showed certain equivalences between networks of simplified neurons and Turing machines, alias digital computers. <McCulloch, Warren S., and Pitts, Walter H.: "A Logical Calculus of the Ideas Immanent In Nervous Activity", reprinted In McCulloch, Warren S.: *Embodiments of Mind*, The MIT Press, Cambridge, Massachusetts, 1965> Armed, then, with the generalized power of Turing computability (and the hubris to consider all possible computation to fall within it, a position now shown to be even theoretically untenable, by Deutsch <Deutsch, D.: "Quantum theory, the Church-Turing principle and the universal quantum computer", *Proceedings of the Royal Society*, London, 19xx> and others), workers in AI marched ahead even while the original problem formulators sought answers elsewhere. And McCulloch, while always seeking to understand the fabric of intellect, always maintained a human and biological perspective. In his collected works, 'Embodiments of Mind' (whose first introduction was written by Papert) he ends one paper <McCulloch, "Why the Mind Is in the Head", reprinted in McCulloch: *Op. Cit.*, pp 87> with the words

'The joy of creating ideas, new and eternal, in and of a world, old and temporal, robots have it not. For this my Mother bore me.'

Ross Ashby was a mathematician who continued in the tradition of Norbert Wiener and Claude Shannon to produce set-theoretic formulations of concepts that were otherwise too complex to easily grasp. One of Heinz's favorite stories about Ashby and one I have heard him retell many times, was about the time when Ashby's students came to him, Heinz, as head of the laboratory, to complain of how simple the material was that their teacher, Ashby, was presenting. When Ashby was told this, his eyes lit up with pleasure as he replied, 'It has taken me twenty years to make these ideas seem simple ...'

Ashby built machines whose behavior mirrored that of living systems; for example, his 'Homeostat' <Ashby, W. Ross: *Design for a Brain*, Chapman and Hall, London 1960> showed that a relatively simple organization could maintain the 'viability' of an organism in its environment, namely its continued, living existence, by maintaining internal conditions in appropriate response to the changing environment. If an organism could do so under all potential variations in the environment, the organism itself is said to have 'requisite variety' --- that variability necessary to respond to the changing demands of the environment. (The application of this to corporations was the foundation of the work of Stafford Beer whose many books <See Beer, Stafford: *The Brain of the Firm*, John Wiley & Sons, New York; *Heart of the Enterprise*, John Wiley & Sons, New York, 1979> on the subject have established the influence of cybernetics and systems science on management consultancy.)

With nearly 100 publications and two books widely translated and widely read, Ashby's contribution stands at the door of the spread of early cybernetics, beyond the complexity of Wiener's mathematics yet before its full flowering as the epistemological stance of second-order.

Ashby would say 'Cybernetics stands to the real machine --- electronic, mechanical, neural or economic --- much as geometry stands to a real object in our terrestrial space.' <Ashby, W. Ross: *Introduction to Cybernetics*, Chapman and Hall, London 1960, and available in PDF from <http://pespmc1.vub.ac.be/ASHBBOOK.html>>

Continuing this sweep backwards to the roots of the field called cybernetics in this century and on this continent (just to make our narrow little context quite clear), before Heinz ran the BCL

there was a series of conferences funded by the Josiah Macy Foundation. <Most extensively described in Heims, Steve, *The Cybernetics Group*, MIT Press, Cambridge, 1991> These took place from 1946 to 1953; there were 10 in all, and everyone was there: Heinz, McCulloch, Margaret Mead, Gregory Bateson, John von Neumann, Conrad Lorenz, Wiener, and I name only the most famous. The title of the conferences was 'Circular Causal and Feedback Mechanisms in Social and Biological Systems.' It was here that social and anthropological applications of cybernetics were newly discussed; and the potential for cybernetics to unify the soft and hard sciences was first implied. The word 'feedback' entered our every-day vocabulary starting here, though admittedly the control engineers had already used it to describe corrective information in electromechanical systems.

Norbert Wiener is, traditionally, the first person mentioned in any discussion of cybernetics. His book, called "Cybernetics, or control and communication in the animal and the machine ." <Wiener, Norbert: *Cybernetics, or control and communication in the animal and in the machine* , MIT Press, Cambridge, Massachusetts, 1948> is a mathematical cyclone at the center, bounded by quite lucid discussion of the early history of the field in the Introduction, and psychological and social implications in its closing chapters. The Introduction credits many co-workers, especially Arturo Rosenblueth, and tells of the Macy meetings from Wiener's point of view.

Wiener wrote in the same year of the publication of the book, 1948, that:

'Cybernetics is a word invented to define a new field in science. It combines under one heading the study of what in a human context is sometimes loosely described as thinking and in engineering is known as control and communication. In other words, cybernetics attempts to find the common elements in the functioning of automatic machines and of the human nervous system, and to develop a theory which will cover the entire field of control and communication in machines and in living organisms.' <Weiner, Norbert: *Cybernetics*", *Scientific American*, November 1948>

Notice immediately that Wiener did not fall into the trap of answering the question 'What is cybernetics!' He explains the purpose of the word and its domain of study, but does not say 'Cybernetics is --- dot dot dot.' I believe this is because he understood the trap, and all of the problems inherent in so-called 'first-order' cybernetics, even while he was purveying its ideas. It is said that although his writings did not much reflect it, Wiener understood the implications that a second-order development of cybernetics would have for the traditional disciplines, and academic enclaves, of soft and hard sciences. <Discussion among Ranulph Glanville, Gordon Pask and others at meeting of London Society of Cybernetics, held at the Architectural Association, London, 1980> Although he was always referred to as 'MIT's Norbert Wiener' by MIT publicity, neither he nor his students were ever fully accepted there. The technological and scientific power that MIT did (and still does) represent could not (and still does not) absorb the implications of second-order; for this reason, Wiener (and others since) were not happy there. <Private communication with Eduardo Caianiello, 1980>

## 10. The Start of New Cybernetics: At its Origins, in the Parable of the Thermostat and the Concept of "Control"

Pangaro: Wiener's contributions included the aiming of weapons during World War II --- at least, in concept. In this, the start of our modern age, the weapons were being aimed at targets moving so swiftly that to aim at the target was to miss: it would have moved by the time the projectile would arrive. So anticipation was necessary, and you had to aim where the target *would be*, and take into account how the target was moving. To automate this process in some type of mechanism required the following elements that, once pointed out, we all recognize are

very much a part of our way of thinking in the modern age. The elements are:

- having a goal, namely, to hit the 'target', whether literal or metaphorical
- projecting into the future and acting according to that projection
- keeping track of how it is going and modifying actions along the way to maintain the given goal(s).

All these elements are crucial to the concept of 'control' that is inherent in the origin of the field of cybernetics. But even from the brief look back I have just given, you can see how the word 'control' does not even hint at the expressive sweep that cybernetics has in its second-order form. And this must be remembered whenever you consider how to describe, even just to yourself, when cybernetics is [sic].

Wiener wrote over two hundred papers, many fully mathematical, expounding and extending concepts of information and control independent of the mechanisms that embodied them. Hence his desire to name a field, cybernetics, concerned with a theory and practice of information and control. The contribution to be made was of a field, not *inter-disciplinary* as if moving between different areas of application, but *trans-disciplinary* in the sense of moving beyond or surpassing defined areas of application such as chemistry, biology, physics, anthropology, logic, computation science, neurophysiology, sociology, psychology, management.

But to say that cybernetics is about 'control' is to say that philosophy is about 'thinking': it may basically be true, but without much qualification we are quite misled. 'Causality' is another one of those problem concepts. We all know about how A can cause B which causes C, and we take these descriptions for granted; namely, we take them as true --- really we do. But let us consider a very, very simple and mechanized system that has such a chain of causality and see its consequences. Which brings us to our next story, that of the thermostat. Consider a thermostat, which we say has as its purpose to maintain the warmth of the room within certain limits. <Long the cliché example of feedback in systems and hence representative of what cybernetics is about, the case of the thermostat and circular control is handled deftly and with great power by Glanville, Ranulph: "'What a Waste' (an unlearned paper)." It is important to note and to praise Glanville's expostulations on black boxes, for example In Glanville: "The Form of Cybernetics: Whitening the Black Box", from *Proceedings of the Meeting of SGRS/AAAS*, Houston, 1979, Society for General Systems Research, Louisville, Kentucky, 1979> How does the thermostat do this? Well, one description would be that it senses the temperature of the room and if necessary, turns on the boiler --- controls it, that is. The boiler in turn controls the temperature of the radiator, which in turn controls the temperature of the room that in turn controls --- what? Lo and behold, it controls the thermostat. What have we learned from this simple but interesting example?

- Control appears to be distributed throughout the system, rather than residing in a single location.
- Systems can be closed; for example, this one appears as a loop. It is the observer who opens it to say how A causes B and so forth.
- Our model of the system and the system itself are not the same; *{hitting the irony again} really, it isn't.*
- The observer opens the system and distinguishes its components. This is far more arbitrary than we might think at first blush: why not speak of the electrons in the wires being

controlled by the power source; why not describe the thermodynamics of the system whose aggregate behavior we call heat? These are obviously unnecessary to our point in the parable. To adequately describe a system is to satisfy the observer's needs; the rest is taken on faith, as part of the ethos in which such systems are described, part of their culture.

- All descriptions of systems are relative to some purpose for that description, and consist entirely of interactions between components of the description (see above).
- 'Control' is an attribution made by the observer alone.

So there is my litany of points about circular causality. Consider that everything said about so simple a system must also be said of all, more complex systems, whether made of metal or meat or man. Wiener and the others knew of these epistemological issues and of their scope; but they chose, at least in the early days, to discuss them mainly in terms of social, anthropological systems. That must have seemed safer at the time.

## 11. The Rise of Second-Order Cybernetics: A Shift from Absolute (external) to Relative (internal), as in from "What" to "When"

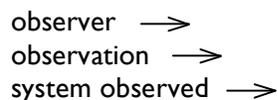
Pangaro: The issue of the attribution of control is the basis of the shift from what is called first-order cybernetics, which is about control, to second-order, which is about bringing the observer to admit that it is the observer that makes the attribution of control. There are two further situations that admit further complications:

- when the observed is also observing, i.e., when I observe a system that is itself capable of observation and description, and then
- when the observed is the observing, i.e., when 'they is us.'

To consider these more complicated cases, and thence to extend our domain of application of second-order from mechanical systems such as thermostats into psychological and social domains, I should add a few tools and a few derived descriptions, as follows.

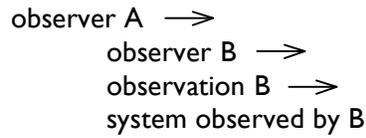
First I can break down the observation process a bit further *{placing an overhead on the projector, Figure 1}*.

*{Figure 1}*



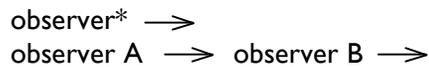
The arrows stand for 'leads to'; the final arrow implies a continuance, to further cycles that include observer, observation and system. We pretend, for a moment, that this is the situation, but there are a few problems with it. For the observer in the diagram, there is no distinction between the observation and the system observed; there is no other path of access. This is the primary epistemological remark. However, we as outside observers can make such a distinction (i.e., we open the loop and distinguish the components), and who are we? Observers of the interaction in the above diagram, observers outside what we have shown. Well, as good second-order epistemologists we strive to include in our description the fact that we understand that this is our position, perhaps thus *{showing Figure 2}*.

{Figure 2}



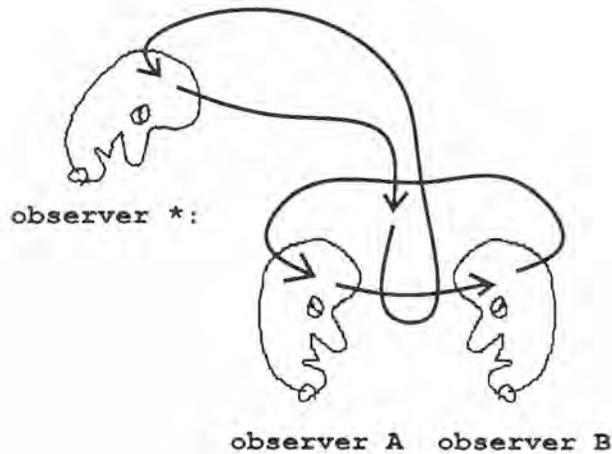
Sometimes there is co-observation going on, and when the distinction of observation and system observed is lost, and there is symmetry across the interaction, itself observed, we need one more layer {showing Figure 3}

{Figure 3}



{He draws above "observer A" and "observer B" the figure of a head, each looking at the other; he draws a loop around them as if they are interacting. Then around "observer\*" he draws an angled head, observing the observing between A and B, as in Figure 4.}

{Figure 4}



This is what Ranulph Glanville calls 'Observing systems[,] observing observing systems[,] observed.' <Glanville, Ranulph, "What a Waste' (an unlearned paper). ", Op. Cit> And either observer A or observer B can take the role of observer \*; and this is what we do constantly as cognitive creatures.

When the shift explicitly occurred, the shift to the observation of systems that themselves could observe, second-order, or New Cybernetics, came into its own. The subjectivity of observation was inherent, as we have seen from the parable of the thermostat, from even before the field

was named by Wiener. However it was not explicitly drawn out. You can imagine the difficulty of the early workers in cybernetics to revise the infra-structure of the scientific community by pointing out that what its members observe, and how they observe, is a function (at the least, in part) of their own imagined purposes, rather than absolutes of the universe waiting to be uncovered <Heinz goes at this brilliantly in his paper, "Order/Disorder: Discovery or Invention?">. Perhaps more easily you can imagine the reluctance of the scientific community to being taken to bits by this new field that could not even stake a claim to a specific domain, as every other self-respecting [!] discipline can do.

But even the scientific position is subject to the observer, just as always are the distinguishing features that the observer chooses to, or is able to, apprehend as distinctions in the 'environment.' What we observe are distinctions; when there are no distinctions there is no nothing [sic]. Edges, boundaries are the obvious case. Components of a system that we choose to delineate and study are another. Logics of distinction have replaced number and measure as the starting place in formal mathematics. <For a most lucid account, see Kauffman, Louis H.: "Self-reference and recursive forms", *Journal of Social and Biological Structures*, Number 10, pp 53-72, 1987>

Adding observations about observers, there are many conditions of distinction that we can describe about ourselves: how I just was a moment ago, how I have changed, how that was not like me. The multiple views of self-reflection are a slippery slope of trying to pin down a description of myself while I myself am changing. I am both the subject and object, the one who stands outside myself looking toward myself, describing, all the while knowing I cannot really be outside myself, for I need the inside of myself to be doing the describing. Hence I am subject to all the problems of observer statements noted above. But I observe myself observing in a recursive loop nonetheless.

This is perhaps no better expressed than by a literary character called Mr Palomar, the invention of Italo Calvino in his book of the same name <Calvino, Italo: *Mr Palomar*, English edition translated by William Weaver, Harcourt Brace Jovanovich, Inc., 1985>. Mr Palomar, like his namesake the observatory, is constantly viewing the universe, and yet constantly vibrating between cybernetic cravings for a clean epistemology and the quotidian (that is, the "daily, every-day") humdrum experience of life. Calvino produces the brilliant descriptions of this poignant juxtaposition with great humor, as in this section entitled 'The World looks at the World':

'But how can you look at something and set your own ego aside? Whose eyes are doing the looking? As a rule, you think of the ego as one who is peering out of your own eyes as if leaning on a window sill, looking at the world stretching out before him in all its immensity. So, then: a window looks out on the world. The world is out there; and in here {*Pangaro points to his temple*}, what do we have? The world still --- what else could there be? With a little effort of concentration, Mr Palomar manages to shift the world from in front of him {*miming the actions of shifting the world from his head to the sill*} and set it on the window sill, looking out. Now, beyond the window, what do we have? The world is also there, and for this occasion has been split into a looking world and a world looked at. And what about him, also known as "I", namely Mr Palomar? Is he not a piece of the world that is looking at another piece of the world? Or else, given that there is world that side of the window and world this side, perhaps the "I", the ego, is simply the window *through which* the world looks at the world. To look at itself the world needs the eyes {*pause, looking at the audience*} (and the eyeglasses) of Mr Palomar.

'So, from now on Mr Palomar will look at things from outside and not from inside. But this is not enough: he will look at them with a gaze that comes from outside, not inside,

himself. He tries to perform the experiment at once: now it is not he who is looking; it is the world of outside that is looking outside. Having established this, he casts his gaze around, expecting a general transfiguration. No such thing. The usual quotidian grayness surrounds him. Everything has to be rethought from the beginning.' <Calvino, *Op.Cit.*>

Francisco Varela expresses the same concepts by saying:

'What we ourselves [typo as printed] perceive, whether we call it frog, landscape, or mirror image of ourselves, is simply what we perceive; and since we have no way of looking at ourselves and our environment from outside our own experience, we have no possible independent access to whatever it might be that, by analogy to the frog, we would like to hold *operationally* responsible for our perceptions. Strictly speaking, we *do not have access to our cognitive domain*, for we cannot step outside it and see ourselves as a unit in an environment. [*italics as originally printed*]<Varela, Francisco J.: *Principles of Biological Autonomy*, Elsevier North Holland, New York, 1979, p. 274>

The double whammy: all observation is subjective, and the study of self is a layering of subjective on subjective. 'Observing systems observing observing systems observed.' So it would appear that all we have is a shifting sand, a complete flux where nothing is permanent. However this is not the case: there is full stability in agreement. Or, as the Rockefeller Center building in New York City tells us, painted over the main entrance with a figure of God out of a Blake illustration, 'Wisdom and Knowledge shall be the Stability of Thy Time.'

## 12. Validated Subjectivity: Scientific Discourse as Recursive Consensus

Pangaro: The most difficult area in which to integrate the shift from reality to subjectivity is that of science itself, because nowhere else is (that which is called) 'objectivity' so highly revered, and such importance placed on consistency, reality, knowledge. {*He looks up as if to say, 'Sound familiar?'*} How could science deal with the extreme statement, What if there were no reality? Milder is, what if I have no access to reality? Or, least upsetting, What if I do not / can not / will not know whether there is a reality?

Maturana (Chicho) approaches the apparent problem presented by science in a cybernetic framework as follows:

'Scientific explanations are generative explanations. That is, scientific explanations are propositions of mechanisms (systems) that:

- a) generate the phenomena to be explained as a result of their operation; and
- b) are accepted as valid in the community of scientists because they satisfy the conditions that constitute the criterion of validation of scientific statements which this same community has established. These conditions, usually viewed as the scientific method, are the following:
  - i) A description of the phenomenon to be explained. This entails the specification of the phenomenon to be explained by specifying the conditions that an observer must satisfy in his or her domain of experiences in order to observe (witness) it.
  - ii) A proposition of an explanatory hypothesis as an *ad hoc* mechanism (or system), that by its operation generates the phenomenon to be explained in the domain of experiences of the observer.

- iii) A deduction through the operation of the explanatory mechanism in (ii), of another phenomenon not considered in its proposition, and the description of the conditions under which it would be observed.
- iv) The observation of the phenomenon deduced in (iii) by an observer satisfying the required conditions in his or her domain of experiences.' <What is it to see?>, reprinted in *Cybernetic*, Vol I Number I, p 60>

This closed and recursive description is sufficient to explain the scientific process. But now comes the triumph:

'A serious examination of this criterion of validation of scientific statements reveals a system of operational coherences that has no need of objectivity in order to operate. Or, in other words, it is not the case that for us to make scientific statements it is required a world of objects.' [sic] <Maturana: *Op. Cit.*, p. 60>

### 13. The Shift of Value and the Rise of Ethics: Truth into Agreement

Pangaro: 'Scientific knowledge', therefore, becomes 'agreement within the scientific community.' Even in science, 'Truth', to put it simply, becomes that which we agree upon. If we take science as a worst case (in its demand for rigor and the highest quality of observation and confirmation) and yet still support consistency within subjectivity, then we may have a means to span all endeavors of the human organism, the human spirit, with a single approach.

Such a 'unified theory' would be reason enough for the approach; but the advantages of adopting the notion of subjectivity over that of reality are many. That which is valued is that which is shared (agreed upon) rather than given (outside and waiting to be absorbed). The relativity of knowing allows a sensitivity for individuality --- because it makes a distinction between 'you must' and 'you might.' It doesn't force compliance or even seek it --- no, relativity allows each side in a subjective exchange to make suggestions and even co-design the trajectory forward (in the design of a poster, say).

Whereas an 'absolute' is inherently insensitive because it wants to force a result rather than negotiate or co-evolve it. Hence it is a weaker and slower process than relativity.

Its 'politic' is different too, then. In a pretense to absolutism, objectivism provides for domination without argument. In subjectivism there can only be the weight of argument as I myself present my argument. I may also argue with the asserted convictions of others, but I am forced to take responsibility for what is in fact my argument. The substitute for power is what, then? Gordon Pask and Chicho argue for the term 'love'; this is also supported by Evelyn Fox Keller in her dissection of the Genderization of Science. <Fox Keller, Evelyn: *Reflections on Gender and Science*, Yale University Press Haven, Connecticut, 1986>. This theme will return much later.

We open floodgates by allowing (or insisting) on this shift. So many disciplines have responded, sometimes with a full embrace of second-order, sometimes with agreement for its consonance with existing metaphors within that discipline. What I mean is, some stepped up to it, and some stepped aside.

In the discipline of philosophy, constructivism views the world as constructed rather than discovered. As a brand of epistemology, constructivism is concerned with how we acquire knowledge and how reliable and 'true' that knowledge is. To the metaphysical realist, knowledge matches reality, as a color patch matches a color; the constructivists, {wryly} especially the radical ones, consider knowledge as a key that fits to open a door <von Glasersfeld, Ernst: "An Introduction to Radical Constructivism", reprinted in *The Construction of Knowledge, Contributions to Conceptual Semantics* Intersystems Publications, Seaside, California, 1987>. These and other metaphors are the realm of Ernst von Glasersfeld, and Ernst has documented this inside history of philosophy and I leave to his eloquence all further details.

Literary deconstruction has been in the mode of observer-based experience for some time. With its emphasis on 'the text', the author is disregarded along with the 'historical' context in which it was written --- the subjectivity of the reader is all that is present any longer. Anthropology has these issues too, especially in the rejection of ethnographic reportage, and the interpretation of cultures otherwise unavailable to our current sensibilities. Here again Mr Palomar experiences the essence, while touring an ancient Toltec ruin in Mexico. His friend and guide has been interpreting all that there is to see: the correspondences between the images carved in stone and the meanings that they held for the ancients who carved them. But all the while, woven into their survey of the past, a teacher and a group of students, perhaps descendants of this ancient people, also tour the ruins but with different interpretation:

'The boys go by. The teacher says: "This is the Wall of the Serpents. Each serpent has a skull in its mouth. We don't know what they mean." ' Mr Palomar's friend cannot contain himself: "Yes, we do! It's the continuity of life and death; the serpents are life, the skulls are death. Life is life because it bears death with it, and death is death because there is no life without death..." 'The boys listen, mouths agape, black eyes dazed. Mr. Palomar thinks that every translation requires another translation, and so on. He asks himself. "What did death, life, continuity, passage mean for the ancient Toltecs? And what can they mean today for these boys? And for me?" Yet he knows he could never suppress in himself the need to translate, to move from one language to another, from concrete figures to abstract words, to weave and reweave a network of analogies. Not to interpret is impossible, as refraining from thinking is impossible. Once the school group has disappeared around a corner, the stubborn voice of the little teacher resumes: "No, es verdad, it is not true, what the senior said. We don't know what they mean." ' <Calvino: *Op. Cit.*, p. 98>

Having given up apparent certainty about our past (and what about our present) we gain other assurances. In preferring agreement over truth-as-knowledge we make our internal values binding, rather than accept values from outside. We remove the confines of external power by refusing extrinsic values, which tend to disperse rather than bring together. (Of course in this context we interpret 'inside' as 'within our associations' whether inside or outside of our heads; external then means 'outside these embraced associations.') We exchange that which is 'static and given' with that which is 'dynamic and negotiated.' But, as Varela warns, we cannot fall into a further trap of throwing anything away:

'The successor to objectivism is not subjectivism, by way of negation, but rather the full appreciation of participation, which is a move beyond either of them ... [Yet it] is by no means easy to adopt this participatory epistemology. Years of efforts directed at demonstrating a correspondence between "knowledge" and an ontological reality are deeply ingrained in our languages and have been foisted on us from the moment we were born. The claim has been "to tell it like it is" rather than to explain how we come to see it the way we do see it. The tradition is strong, overpowering. Even in one's own thinking, no matter how determined one may be to break away and start afresh, one inadvertently

falls back into the conventional track and sees problems where there is no problem. Traditionally we are supposed to play the role of discoverers who, through their cognitive efforts, come to comprehend the structure of the "real" world. Thus we are always prone to revert to some form of realism and to forget that what we are thinking or talking about is under all circumstances our experience and that the knowledge we acquire is knowledge of invariances and regularities derived from and pertaining to our experience.' <Varela: *Op. Cit.*, p. 276>

There is no loss to science, neither. If Chicho's four points are a valid description of the action of scientists, then its internal consistency, as opposed to external validation, is what has been happening all along anyway. To embrace participation is also to reject a genderization of science inherent in the objective/power/male view. <Fox Keller: *Op. Cit.*>

#### 14. Recapitulation

Pangaro: I have shown how a shift of notion from reality to subjectivity, and from knowledge to agreement, is a shift from first-order to second-order positioning. Second-order emerges as a reasonable way to model or catch the actions of us all, perhaps even something to strive for. Along come advantages of an ethic that the shift brings with it. Now we are ready for the third aspect of shift, that from a concept of inside/outside to the concept of experience.

#### 15. Closure and the Closedness of the Nervous System Input/Output and Domains of Interaction

Pangaro: OK, so now it is time to resolve a puzzle you have (probably) had in your minds for some time. This 'inside/outside' stuff I am hawking seems to conflict with our common sense: 'There is surely an inside to my head', you are thinking, and boundaries between you and me are evident --perhaps even stronger, to your perception, than the ties of society, language, common biology that bind us together. Again I would claim that this is an artifact of our present-day culture rather than a given, external truth that we must swallow and live by. Here is my argument, as bolstered by the usual quotations.

Starting from physical boundaries, clearly we observe that organisms have insides and outsides: their skin or shell or membrane defines the distinction between themselves and their environment. In this sense they compute their own boundary, because the processes of development create their physical edges and the difference between inside and outside. This capability was first named by that group of Chileans, Maturana, Varela and Uribe <Varela, Francisco; Maturana, Humberto; and Uribe, Ricardo: "Autopoiesis: the Organization of Living Systems, Its Characterization and a Model", *Bio Systems*, 1974, 5: 187-196>, as 'autopoiesis', from the roots 'autos', meaning 'self', and 'poiesis', meaning 'to produce.' Varela offers the description:

'An autopoietic system is organized (defined as a unity) as a network of processes of production (transformation and destruction) of components that produces the components that: (1) through their interactions and transformations continuously regenerate and realize the network of processes (relations) that produced them; (2) constitute it (the machine) as a concrete unity in the space in which they exist by specifying the topological domain of its realization as such a network.' <Varela, *Principles of Biological Autonomy*, *Op. Cit.*, p. 13>

The form of this description is one that you get used to as you read the literature, especially as written by our Chilean friends. What sounds like tautology or repetition is actually careful second-order activity: ensuring that the description takes into account what can be said by an observer. This comment is also true of the concept of the *{pronounced as if a bit Elizabethan, in three syllables}* closed-ness and closure of the nervous system. This is one of Chicho's major points that, at first, has the quality of the impossible or the absurd; and yet it has major implications for AI research.

Carrying on the image of the organism as having a physical outside and inside, let us ask the question about its perceptions of the environment --- rather, what the observer calls the environment (I caught myself that time).

Take the case of an organism that has eyes to see. Now does not this organism 'take input' from the environment through its eyes, perform some transformation in its nervous system and brain, and provide some 'output', in the form of actions, as a result of this input? From one perspective, that of conventional biology, yes. But another view is:

1. The nervous system is closed to the observer; nothing that occurs in it is available to the observer and hence the judgment that it 'takes input' cannot be confirmed.
2. 'Taking input' cannot be confirmed because it would require 'seeing inside' the nervous system, and specifically being able to see the 'meaning' inside in the way that the organism does, not merely the electrical activity as a result of some stimulus.
3. Hence, though the organism may have a distinguishable inside and outside in the physical sense, to the observer the nervous system neither takes input nor provides output to the environment.

This is worth explaining, though it will take some effort, perhaps on both our parts.

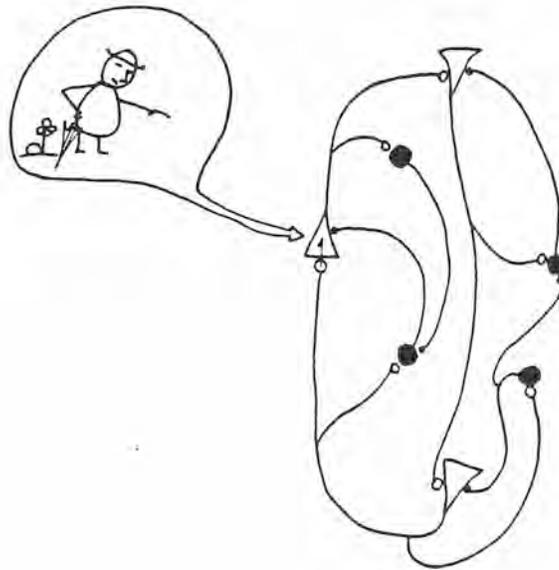
To understand what it means to say that the nervous system is closed requires the idea of operational closure. This means that whenever operations are performed on variables of some type, the result is always of the same type of variable. *{Moving ahead quickly}* At its simplest consider the addition of numbers; no matter what numbers are added or how many times, the results are always *numbers*. So we say that addition is a *closed* operation. Of course when the domain is that of nervous system activity, the operations are more complex than simple addition and the values are of much greater dimension than simple numbers (this sounds just like our qualification about Eigen values and functions). Nonetheless, the result is still further nervous activity, no matter how much nervous activity there has been, or under whatever conditions that occur (so long as the organism retains its identity and does not become something else or get destroyed; this is what the concept of autopoiesis provides).

Chicho says, and if Chicho were here he would say *{imitating him at first, by raising his voice in pitch to emphasize the first word}* 'I say:

'A nervous system is a system organized as a closed network of interacting neuronal elements (including receptors and effectors among these *{Pangaro looks up from the page and interjects 'such as eye and muscle, ears and voice'}*), that interact with each other in such a way that any change in the relations of activity that takes place between some elements of the net, leads to changes in the relations of activity taking place between other elements of the net ... *{interjecting again, 'i.e., changes here make changes there'}*. As a result of this operational closure, all that takes place in the operation of the nervous system are

changes of relations of activity between its component elements. The sensory and effector surfaces of the organism are not an exception to the closure of the nervous system ... What is peculiar to the effector and sensory surfaces of an organism, is that we as observers stand between them as if we had opened a synapse and defined its synaptic gap as the environment <This and subsequent figures and quotes of this section from Maturana, 'What is it to see?', *Op. Cit.*>

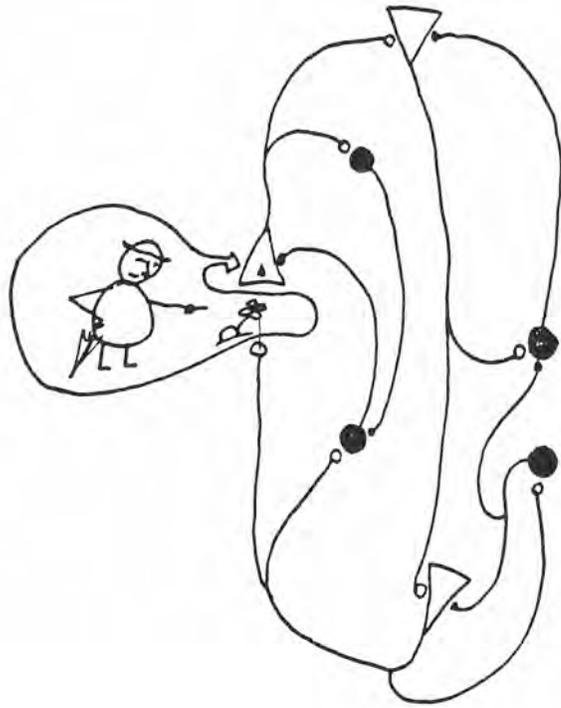
Figure 5:



Pangaro {placing Figure 5 on the overhead projector}: Here we have a figure drawn by Chicho, showing the nervous system (represented by just a few loops) as connections between neurons {pointing to the triangular shapes} and synapses {pointing at small round dots touching the neurons}, with the loops closed by thin lines with arrows, these are axons, which for our purposes here can be considered transmission lines. As you know, electrical impulses travel along the axons, enter the synapses and cross a gap, called the synaptic gap, to the neurons. Note especially that the entire system loops back on itself, and there is no reference to an 'outside.' Notice too the figure of an observer, who is interacting with it with a different sort of arrow, an open arrow. This arrow {pointing to it} impinges on the nervous system in a manner that is 'orthogonal', that is, at right angles to, really indicating a range of interaction in different dimension from its normal operation. The caption reads, in part {reading}:

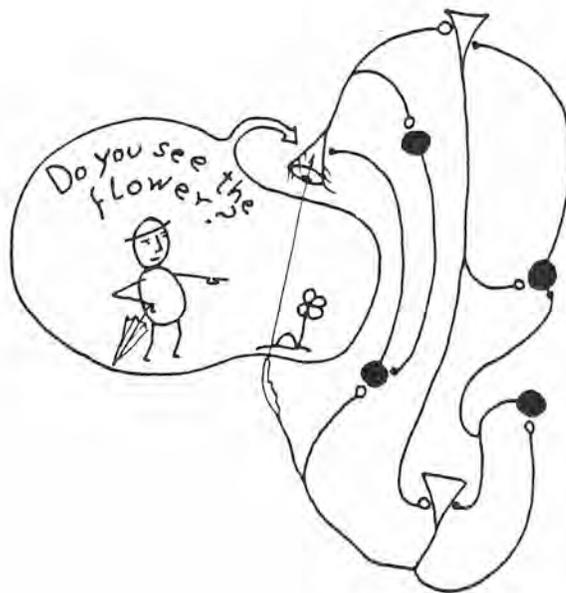
'The observer looks at a nervous system as a closed neuronal network, and interacts with it interacting with its components in a structural domain orthogonal to its dynamics of states.'

Figure 6.



Pangaro {replacing the image with Figure 6 on the overhead}: Here the observer opens this gap between the synapse and neuron and considers one side a sensor (the eye is a type of sensor) and the other side an effector (the hand is an effector, but the formulation of a concept is also an effect). {Pause.}

Figure 7.



Pangaro {replacing the image with Figure 7 on the overhead}: Now the sensor side is drawn like an eye, while at the same time another sensor, the ear, is part of the interaction, as the observer asks the question, 'Do you see the flower?' It is a construction of the observer that the flower exists in a gap in the nervous system.

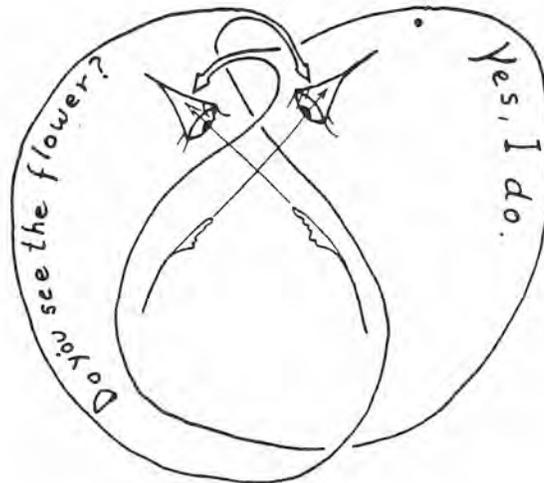
{Reading the caption}:

'The observer by stepping in the synaptic gap defines his or her domains of distinctions as the environment of the nervous system. For the observer there is a flower in the environment; for the dynamics of states of the nervous system as a closed neuronal network there is no flower, only a synaptic gap that is not a gap.'

When I first read this I was overwhelmed: I felt trapped in my own body, nervous about my nervous system. For the first time in my life I understood the pathetic figure in Rodin's *Burghers of Calais* with his hands and arms wrapped around his head in horror.

And we might well fear solipsism. But our bodies do not exist alone. We must include consideration of the reflexive responses of the organism whose nervous system we have studied and provided with a synaptic gap. When the organism under scrutiny performs the same move, by stepping into the synaptic gap of the aforementioned observer and causing an interaction that is in a different domain than that of the nervous system, this is the result {showing Figure 8 on the overhead}.

Figure 8.



The caption is:

'Structural dance of two interacting organisms with closed nervous systems that perturb each other structurally, but which, even though they stand opening each other at the effector sensor synapse, do not constitute inputs to their respective closed nervous systems.'

So we stand in each other's synaptic gap, and we agree that we are standing in a world that has flowers. The nervous system can stay closed to the observer, and yet we are not doomed to be solitary, or to solipsism.

{Pause}

The implications of this view are immense. Here is a descriptive form in which we can have the clarity to say what can and cannot be known. We do not have access to the internals of another's nervous system because we cannot refer to anything inside of it to obtain a mapping of its internal states to what we can reference as outside of it. Hence we must be able to avoid needing access to those internals to explain or understand. However we must be able to explain how we intertwine our experiences (Chicho uses the metaphor of 'dance') such that we can agree upon and stabilize our mutual view of the 'environment.' All this under the condition that {reading Maturana's words):

'The environment that we describe, as part of the medium where we stand as observers, does not exist for the nervous system of the observed organism in its operation as a closed network of changing relations of activity between its components ... What is peculiar to the medium in which we usually observe an organism with its nervous system, is not that the medium spans the effector-sensor synaptic gap, but that we stand in it as observers.'

Figure 9.



This last comment seems to stand things on their head. And here is an observer standing in a gap {placing Figure 9 on the overhead}. Here is the 120 angstrom synaptic gap which the observer (and his umbrella) stands in.

'By [standing in the gap] the observer opens the nervous system and transforms the intersynaptic space in the medium where the organism exists and he or she distinguishes the environment ... But ...[t]he nervous system in its operations as a closed neuronal network is blind to what the observer sees as the environment ...'

Chicho says that:

'To the nervous system what happens in the retina happens in a structural domain orthogonal to its dynamics of state.'

I say that what happens in the retina is no more 'input' than what a synapse has to say to a neuron. *{Pause.}* In celebration of this, and in an effort to extend the means to express such ideas, I have an offering for you here of a short Rap Song. I am not below the use of a modern and popular medium to 'lay down' some ideas. The song is called 'The Synaptic Gap, A Representation Rap.' This requires a few props of course *{he reaches down into the podium to retrieve a beret and sun glasses, which he puts on.}* You can imagine for yourself the gold chains, the colleagues in the background dancing and jumping around. Those of you in the audience with similar props are invited to don them. *{Some do so. He imitates the sound of background noises common to rap songs, drum-machine rhythms, etc. He chants:}*

Think of our eyes as access to the skies:  
photons come in onto our photo skin.  
The pictures it bring [sic] do little more than sting.  
A world so imported is always so distorted.  
*{these lines indicate pause in the beat}* --- for the Synaptic Gap --- for the Synaptic Gap.

'Cause the neurons within have as their only skin  
dendrites' touch saying oh-so-much.  
From a neighbor's view  
there's a message coming through  
but it's so far removed from the sky,  
so be behooved.  
Don't fall in the trap, the world's a load of crap:  
--- to the Synaptic Gap --- to the Synaptic Gap.

The nervous system's closed,  
it's only just supposed that the eye takes in  
what's outside to within  
The world that's seen is only in between  
the nervous system's parts; it's not the place that starts  
the swirling train, the pulses in my brain;  
--- it's the Synaptic Gap --- it's the Synaptic Gap.

But don't shed a tear though you won't know if I'm here,  
we might both agree that there's beauty that we see.  
then the neuron's touch is not something that's such  
a thing to reject a lot's there to detect.  
In the world we compute there's so much to impute  
--- with the Synaptic Gap --- with the Synaptic Gap  
--- with the Synaptic Gap --- with the Synaptic Gap.

Pangaro *{removing the hat and sunglasses}*: These same comments apply to the hormonal system, the immune system. Consider too who makes these distinctions of different types and functions of system. One hears now of research showing a unified basis for all these supposedly-distinct systems, somewhere in the white blood cells. *{He begins to quietly hum "Somewhere Over the Rainbow", but stops.}*

## 16. Representation: A World Outside vs A World Among

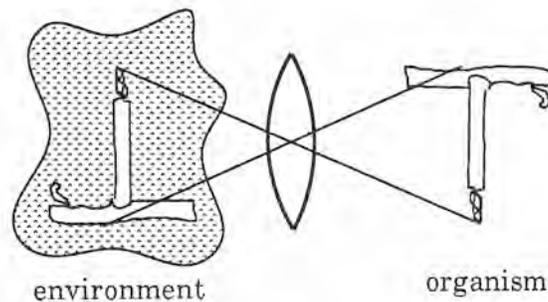
Pangaro: Now the promised answer to the question, Why is the distinction between inside and outside an unfortunate notion, and what is the impact on AI in its revision?

So much activity in AI is spent on the problem called 'representation', usually the representation of knowledge. Within the confines of the paradigm of inside/outside, we can characterize these efforts at representation as follows.

{He places a blank film on the overhead and proceeds to draw Figure 10.}

Pangaro: Here in the designated environment we have an object, drawn as the canonical candle with holder and flame {drawing the objects as he speaks} and we consider that here, inside the organism there results some direct and corresponding thing, alias representation, that consists of parts, each of which corresponds to the parts of the designated original. So a metaphor of this transformation from inside to outside would be that of a lens, which focuses and transforms the original object into some form that is captured by the inside. {Figure 10 is now complete.}

Figure 10.



The transformation is made by a confluence of conditions including the perceptions of the organism. These perceptions are themselves influenced by the past experiences of the organism; for example, the postulate that objects exist and persist in the environment --- but this is Piaget <Piaget, Jean: *La construction du réel chez l'enfant*, Delachaux et Niestl'e, 1937>, himself a constructivist. His anthem was 'Intelligence organizes the world by organizing itself', but more than that we do not have time for here.

I call this interpretation of the term 'representation' a 'I-to-I mapping.' It is this interpretation in which AI is grounded. Those of you familiar with programming techniques and AI will recognize this in the techniques called semantic nets, frames, and even the archaic 'association lists' of LISP, a programming paradigm that has a strong and perhaps subliminal influence on the types of representation that have been developed. We might summarize the position by saying that, in this context, representation is an *investment* in the distinction of the cognitive inside and cognitive outside of an organism. This in turn supports the concept of an 'input' to the organism, leading to a I-to-I mapping of external objects to internal objects.

This investment by the AI community has always been disturbing to me and when I learned of Chicho's approach I was anxious to bring the two views together in some clarifying way. At a conference I heard Chicho use the word 'nonsense' in reference to 'representation', and I asked him a question via the medium of a conference book (a product produced during the event, a concept that is executed by Annetta Pedretti of princelet editions, and itself a cybernetic act of dynamic self-reference) <These next quotations from Maturana are as quoted in Pedretti,

Annetta, and participants: *conversations in cybernetics, conference book*, princelet editions London, 1986>. {Reading}

'Sir: you say that it is "nonsense to view the nervous system as having a representation of the environment." This of course is the nonsense upon which the major history of AI has been based.'

I then asked him to give a response that would explain to *an AI researcher* what it was that he was trying to say. His reply was,

'The nervous system is a structure-determined system, as such nothing external to it can determine what happens in it. External structures (external as the observer sees them) can only trigger in the nervous system structural changes determined in its structure.'

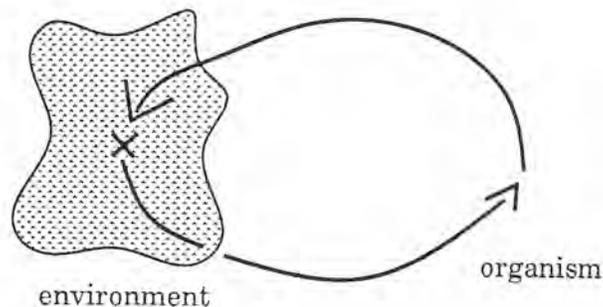
I am sure that by now you recognize the style of discourse and that you accept it for its power even if it brings a wry smile to your lips. {Continuing to read the quotation}:

'It is in that sense, that the nervous system cannot operate with a representation of the medium {Pangaro commenting, "which is what the I-to-I mapping is"}. For the observer a particular structural change that arises in a nervous system triggered by an interaction may constitute a representation of the external structure that triggers it, but not for the operation of the nervous system. It is because of this that to talk of representation in the operation of the nervous system has no sense.'

This last sentence, what a lovely play on sense, senses, sensation. And I love this whole formulation, for it exposes how it is entirely the observer's idea that an input goes into the organism and results in a representation. Clearly there is something going on between what the observer calls the environment and the organism. But what is it that is happening from the organism's point of view such that it can operate with increasing viability and yet can be described in a manner consistent both with it and us as observers? Put more simply, what alternative model is there, to the metaphor of I-to-I mapping?

{He begins to draw what becomes Figure 11.} Here the designated environment appears to the observer to contain some event for the organism. But remember, the environment interacts with the organism in a domain orthogonal to the domain of interactions within the nervous system (see, that wasn't so bad, was it? You are getting used to it). The mapping that the organism performs does not produce a representation of the outside that is inside the organism. Instead the organism produces a representation that maps the 'outside' back onto the 'outside.'

Figure 11.



(I owe the simplicity of this image to a discussion with Heinz; he later sent me a postcard he made from graphics of variations of such mappings, with this one called 'autotopic' --- 'self-place.')

One might say, in high metaphor, that the purpose of the organism is to reify itself by reproducing the environment (its dual) through its functioning; this of course is a complementary way of explaining autopoiesis. This 'through-mapping' or 'through-looping', as I like to call it (a phrase that emerged in the course of extended conversations with Patricia Clough), uses the environment's environment (that is, the organism) to reproduce itself (the environment).

Now all this is somewhat disconcerting, as any argument about obliterating a distinction between inside and outside might be expected to be. I wondered, truly, for some time, about how to explicate these ideas, in a manner that was quite clear, and I believe I have found it in my own basis as a performer. Here is my offer.

Consider the relationship of the actor to the audience. The actor speaks lines from a script (at least in the sort of theatre I wish to discuss, rather than improvisational or *avant garde* or performance art, though each of these may have some or all of the elements I am about to use as analogies). The audience reacts to the performance, the script, the setting, and so forth. The reactions may be laughs, tears, silence; attention or inattention.

Both the actor(s) and the member(s) of the audience exist in their own domain of interactions. By this is meant that the audience, for its own part, does not speak lines of the script to the actor on stage. The actor on stage does not, for his or her own part, provide laughter, tears, attentiveness to the other members of the audience. Now the actor surely has such reactions, but they are within the context of the script and the action of the play and the other actors; they are not interpreted by anyone as 'audience reaction.' Similarly the audience may shout out lines, immediately breaking the distinction of actor and audience, as the audience member truly enters the domain of interaction of the stage situation. But this last situation is outside of the metaphor I wish to expound.

One can say that, within the situation described, the acting, the drama, is a closed system. It is *script-determined* (rather than structure-determined, if you *will* allow a slight cleverness). The domain of interactions of the acting is orthogonal to that of the audience, and the audience response does not provide 'input' to the actors (indeed if it did, we would again have a crossing of the domains of actor and audience, and the closure of the domain of the script would be broken). But if there is no input and output, what is the relationship?

I propose to model it as a looping, specifically a 'looping-through mapping', from the audience, through the organism that is the action of the drama as produced by the actors on the stage, back onto the audience. The audience experience, their lives and histories, are the starting place of comprehension. The function of the actors is, beginning with that shared experience, to enact a representation of it, which then is experienced by (maps back onto) the audience, reproducing both that which the audience has experienced (and therefore can recognize) and that which is novel (i.e., perhaps the experience newly stated, now extended, more intensified, etc.). In an important sense the audience is constructed by the acting, obviously not in a physical sense but in emotional/psychological/cognitive senses. It is often stated that the goal of acting is audience 'response'; I say that this same goal is actually audience invention or construction. And, this is not a cause/effect, input/output relationship, but 'circular causal' because the loop does not stop on one iteration. Because it does not merely go 'back and forth', it is technically not an interaction but a recursive inter-looping.

So I as performer create you: if I were not here, neither would you be. If we all were here, but I did not perform, you would not exist as an audience, my audience, the audience of my performance. If we are both here, and we both agree to perform our respective roles, we create each other --- and this is one of the things I want to do with you today.

So we have a complementary pair: actor/audience, just like nervous system/environment. One problem with this metaphor is that it does not encompass the issue of the genesis of the mutually defining systems: how they arise. This seems to be a limitation, therefore, because Chicho is concerned with this issue *{speaking again in a manner reminiscent of Maturana's Chilean accent}* 'fuuundamendntally.'

Despite this shortcoming I find the metaphor useful; it collapses the points about closed systems and through-looping into the same image. And there is more to come out of it: an exercise for you, the audience, is to consider the case when you, as the organism, are mapping a point in the environment that is your image reflected in a mirror. By application of the through-looping metaphor, I would say that the process going on inside you is that of reproduction of the point in the environment, in this case your own image. Because you have motor control and the feedback loop is so tight, it seems to me that you are locking into a tautology. As an 'I' would look at it, I see an image, I reproduce it through myself and map it back to the image. The 'it' that I reproduce is under my control and then is myself, but the 'I' seeing the image is me.... *{He shudders.}* This collapse unto itself and recursion may explain why in this situation an infant laughs, a dog becomes confused, a teenager looks self-absorbed and pretty damned silly. And is it not strange to be witnessed in these interactions of self with made-self? Why do we hate to be watched while looking in the mirror at ourselves? There is some perceived contradiction of being closed in the loop and yet able to take the position of another, an external observer, and thus being closed and opened at the same time.

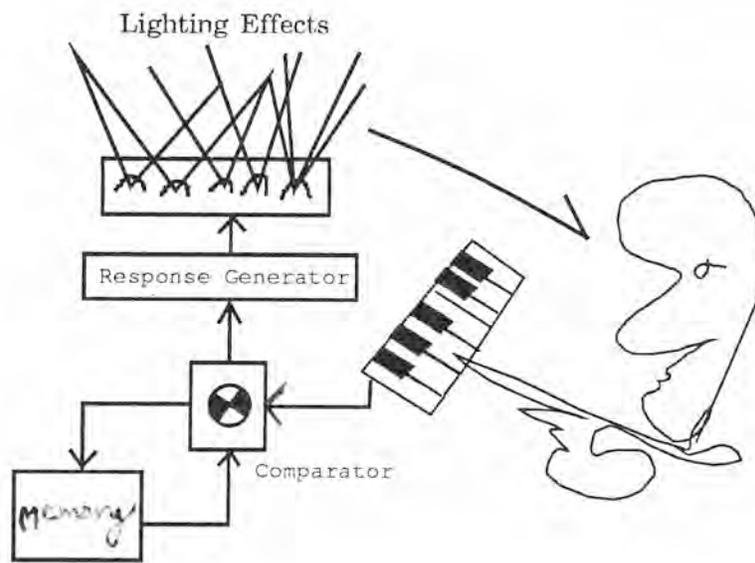
## 17. Implementation: A World Inside vs. A World Through

Pangaro: So, about all this schtick, so what? (So when?) So, well, there *are* clear implications for implementing systems that pretend (or actually do) contribute to the intellect of humans. From our perspective on representation, we can glibly say that symbolic representations diminish in interest; and neural nets appear more interesting, because they can be entrained to learn mappings without pre-defining their program. But more immediately (and more practically), the question is how do we remove the 'inside/outside' and I-to-I mapping ideas, and substitute 'through-looping' in the human-to-system interface --- in fact how do we revise all *premises* (or *pretensions*) of 'inter-action', and replace them with through-looping. First I will describe some actual, historical, artifactual examples of the type of human-to-system relationship that is desired, and then show some more up-to-date versions.

Of course the desire within these investigations is to better describe the relationship of the organism to the environment, and so to enhance the relationship of human to machine. Surely the one leads to the other.

Let me draw a mechanism that was constructed in the 1950s that was one of the first, and certainly *the* first that I am aware of, to provide an experience for a human participant that has the qualities of through-looping I have presented. *{He begins to draw what will become Figure 12.}*

Figure 12.



There is a keyboard instrument, say a piano, whose sound is captured by a microphone. This is fed into a comparator; the output of the comparator loops around into a memory that is really a filter and predictor. The memory is the second input into the comparator, forming a closed loop within the system. The other output of the comparator then drives controllers for a light show, with banks of various colors, blue, red, green, etc. Remember that this is the 1950s and the equipment I am describing required one and one-half vans to carry around England to various dance halls and theatres. The system was called 'Musicolour.' <Pask, Gordon: "A comment, a case history, and a plan", in Reichardt, J. (Ed.): *Cybernetics, Art and Ideas*, Studio Vista, London, 1971, pp 76-99>

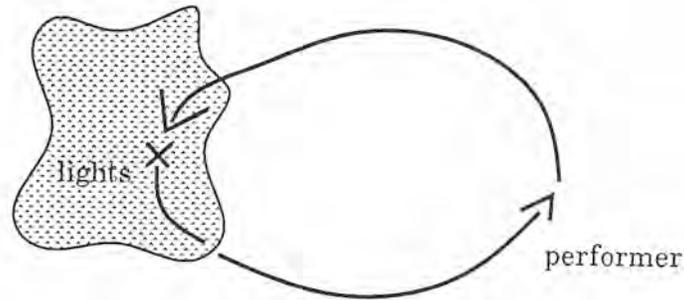
The system was not like a trivial 'light show' of the 1960s, where bass notes of the music made the green lights turn on, high treble notes were displayed as yellow, etc. Instead of this trivial, 1-to-1 mapping that was relatively fixed, the comparator and memory were a kind of 'interest seeker': at first a bass note might be green, but if the note became often repeated and sound continued in the same pitch range, the system would find it 'boring' and look elsewhere, at some other frequency, seeking some variation. Another seeker circuit might happen upon the green lights as a means to express a different range of pitch at another (or the same) time. So the green lights would not always 'represent' a particular frequency. There were five such seekers which were sensitized by a threshold device that ensured that some variation could be found to sync to at most times, and which would form a stable response that would become 'bored' if held for too long. A further circuit did a similar thing with rhythm, where the beat was anticipated and a light would pulsate to it. A small delay, for example, would be amplified and show up as a larger delay in the lights' response that would feed back to the musical performer.

And that is the point, of course, the closure back unto the performer. Slight variations would be emphasized by the mechanism, whether intended or not. Having been amplified out to the performer, the performer then takes notice, increases the variation or suppresses it, follows and leads all at once --- because there is no locus of control. There exists only the system's closure, where the mechanism and the performer form a loop. That which traverses the loop is a shifting focus of attention in a field that cannot be described or understood by an outsider --- at least in the same terms that the participants, the performer and the mechanism, apprehend it. Can we

as observers say whether the mechanism is the environment for the performer, or vice versa? What is inside and what outside? Remember the pencil allegory before you reply.

We would represent this as a re-labeling of our through-looping-mapping, as follows. {Pangaro redraws Figure 11, this time with the point in the environment labeled as 'lights' and the organism labeled 'performer.' This becomes Figure 13.}

Figure 13.



The results as reported by witnesses were, for the performer, total loss of a sense of time; a feeling of intoxication. On an occasion when dancers were used as the source of variation via transducers in the floor and used by the mechanism to amplify into lighting, the performers became so disoriented that they vomited.

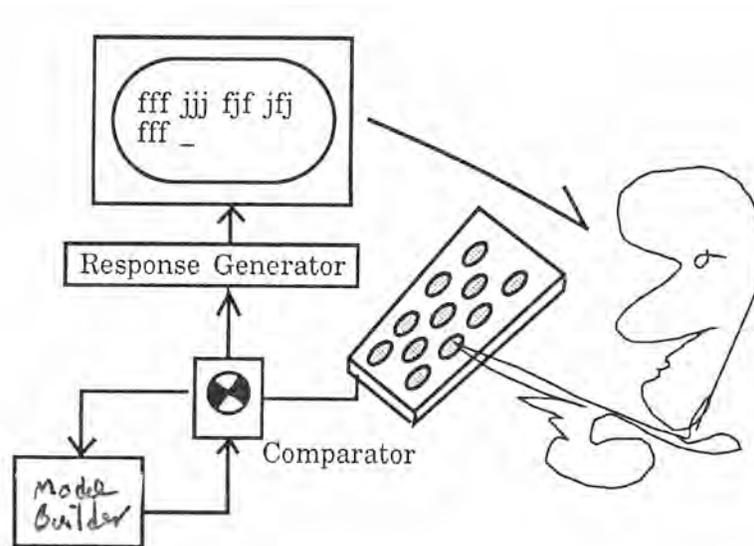
Looking from the perspective of the performer for a moment it would appear that this experience is like living in a world that is not mechanical (though it is made of a mechanical, deterministic machine). It is more like the living, or the living together of what in this case is human and machine. It is not an interaction 'between' but a 'looping through.'

This device was displayed in music halls around Britain --- Dr Pask and his co-inventors extended the entertainments normally available in such places, while preserving one fundamental aspect: the experience was still a through-looping. (I am grateful for his practice as *compere* during that phase of his career, and you now know my joy for his lending such authenticity to our proceedings with his introduction in music-hall style.)

Might this interaction be a model for learning, as an adaptive and intoxicating (and hopefully not nauseating) process? The producers of Musicolour asked this very question and proceeded to apply the idea of the closed, adaptive loop to the learning of keypunching skills. Again, the demands of the era, and the available technology was crude by today's demands: the keypunch was smaller and with fewer keys but had the twist that it required multiple, simultaneous keystrokes to obtain certain characters.

The system architecture was similar to that of Musicolour {he begins to draw what results in Figure 14}. The operator sits at a keyboard connected to a comparator.

Figure 14



In this case a 'model builder' provides the other source for the comparator. This memory alias model builder embodies what is correct typing skill: hitting the proper key while keeping a consistent rhythm. The comparator feeds an exercise generator that provides display data to the screen. The operator views the screen, sees what to type, reacts to the results, and thereby closes the loop.

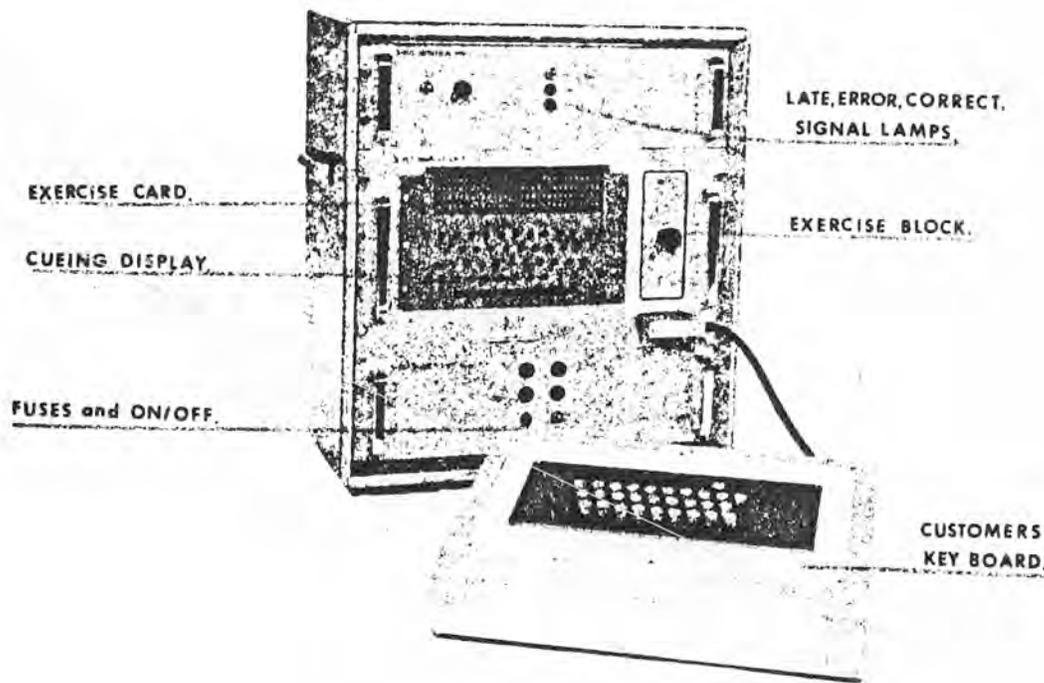
The rough order of events is that at the start a simple exercise is presented: typing the string of characters 'jjj fff fff jjj' then 'fif jfj' etc. The operator responds by following a cue and attempts to type, correctly and rhythmically, what is displayed on the screen. This current result is compared to the model builder and the result controls the next exercise that is presented, as follows:

- . When the operator is doing very well and making few or no mistakes, it is an indication that the exercise is too easy. The operator is not being challenged to learn anything novel and is merely repeating a learned skill. Therefore the complexity of the exercise should be increased, lest time be wasted in the learning process.
- . If, as exercise complexity is increased the operator begins doing very poorly, it is an indication that the skill demands are too high. Little constructive learning is taking place. Therefore the complexity of the exercise should be lowered, and so simplifications of the current exercise should be presented until conditions in 1 above are obtained.

Simplification of a given exercise is a matter of breaking down a given keystroke pattern (say 'fudge') into a combination of skills of the individual key transitions which can be exercised by other keystroke patterns ('fgf', 'fuf', 'fdf' and 'ege'). The system is closed (all exercises are patterns of keys) and recursive (simplifications of simplifications of simplifications...), making for easy implementation.

The close interaction of the control mechanisms of 1 and 2 running simultaneously leads to tracking along the most efficient possible learning experience for this individual operator. At all times the practice is challenging (so learning is taking place) but never so challenging as to be disruptive to learning. Hence the system is called SAKI, for Self-Adaptive Keyboard Instructor.

Figure 15.



This {Figure 15} is a picture of the 1950s version of the special purpose hardware required to embody the idea. The part labeled 'Exercise Block' contains the data that tells SAKI which exercise is being presented to the operator. The 'Exercise Card' is a piece of film that contains the letter sequence that the operator is to follow, and SAKI cues the operator via a sequence of lights that appear behind the letters. The Exercise Block weighs more than 2 pounds and contains a prodigious 128 characters of information. It was literally screwed into the machine via the large knob --- it's difficult to read the scale of the photo, but the knob on the exercise block is 2" in diameter. The 1980s version we have developed is, of course, simply a diskette of software. <Pask, Gordon: "SAKI: Twenty-five years of adaptive training into the microprocessor era", International Journal of Man-Machine Studies, Number xxxx>

Again, as in Musicolour, SAKI creates a closed loop that is responsive and intoxicating because it is adaptive and individualized. The result is not a trivial control system, as in a linear, cause/effect, input/output model of interaction. Here the causality is circular and the resulting system has an autonomy, an integrity that has no reference outside itself. A nervous system, as we have seen, is best modeled as being autonomous. The concept of autonomy is one that is basic to the field of cybernetics and its application in modeling of systems is as basic as a shift from reality to subjectivity.

Varela says:

'Autonomy means, literally, self-law. To see what this entails it is easier to contrast it with its mirror image {Pangaro commenting: "that is, its dual"}, allonomy or external law. This is, of course, what we call control. These two images, autonomy and control, do a continuous dance. One represents generation, internal regulation, assertion of one's own identity; definition from the inside. The other one represents consumption, input and output, assertion of the identity of other: definition from outside. Their interplay spans a broad range, from genetics to psychotherapy.

'We all know control well; it has been charted out and formalized. Hence the power of the computer and of consumer-oriented services. Its popular model is: something in / process / something out ... The fundamental paradigm of our interaction with a control system is instruction, and the unsatisfactory results are errors.

'Autonomy has been less fashionable ... The fundamental paradigm of our interaction with an autonomous system is a conversation, and its unsatisfactory results breaches of understanding...

'The control characterization is intimately tied up with an understanding of information as instruction and representation {Pangaro, "in the I-to-I, input/output sense"} ...[by] discussing autonomy, we are led to a reexamination of the notion of information itself- away from instruction, to the way in which information is constructed; away from representation, to the way in which adequate behavior reflects viability in the system's functioning rather than a correspondence with a given state of affairs.' <Varela: *Op. Cit.*, p. xi-xii>

The question that now presents itself is whether the presentation of conceptual, rather than merely hand-eye skills such as typing, can be presented in a manner consistent with the autonomous model of organisms and within a dynamics that is responsive and intoxicating because it is personalized. What components need to be supplied?

1. An 'expert model' that can embody the 'knowledge' (in quotes of course) of some expert who is considered to know something valuable that a student wants to learn. You will recognize this as the issue of 'representation', already somewhat discussed.
2. Some means to model the student's current condition, or current understanding, of the subject matter.
3. Some means to compare the student's current condition with the expert model, and to generate or choose material for the learner to handle next.
4. An environment, probably of the computer sort, in which all these can be combined and placed in juxtaposition with the learner, to create a closed, adaptive loop that is responsive and intoxicating because, yes, the system closes on itself and even tunes itself, just as Musicolour and SAKI do.

In the following sections I present how each of these components is not only possible but has already been constructed by myself and my colleagues, based on Musicolour and SAKI and generalized by their inventor Gordon Pask. This software-based learning environment is called THOUGHTSTICKER and it is unique in its contribution to human learning via computers, and, indeed, in its contribution to all loops that incorporate humans and computers in the creation of their autonomy.

## 18. Embodiments of Mind: The Micro-Structure of Concepts

Pangaro: I have presented, albeit in brief, how there is a conventional view of 'representation' as I-to-I mapping. An alternative view called through-looping holds advantages.

It preserves the status of observer as one who sees interactions between, say, organism and environment, but who does not have access to the inside of the organism.

1. It yields useful and consistent descriptions of functioning systems, whereas explanations with simple cause/effect relationships are impoverished or misleading.
2. There is an intuitive appeal in that through-looping seems to effectively capture the more subjective experiences of learning, as well as the appreciation of art, and the nature of human relations.

The role of 'information' is enriched, whether in biological, social, or computer-based systems.

Varela says *{reading}*:

'Information, for the computer gestalt, becomes unequivocally what is represented, and what is represented is a correspondence between symbolic units in one structure and symbolic units in another structure. Representation is fundamentally a picture of the relevant surroundings of a system, although not necessarily a carbon copy.

'From the point of view of the natural (including social) systems, the computer gestalt is, to say the least, questionable. There is nobody in the brain to whom we can refer to obtain an assignment of correspondences, and any attempt to view it as an input-output processing machine can be equally well interpreted as the machine's reducing us to an equally allonomous entity *{Pangaro commenting: "notice the nice symmetry here, where both sides of the interaction are treated the same, and so fairly"}*. With any of the variety of natural, autonomous systems, all we have is certain behavioral regularities, which are of interest to us as external observers having simultaneous access to the system's operation and to its interactions. Such regularities, when we choose to call them cognitive and informational, always refer us back to the unitary character of the system at hand, whether a cell, a brain, or a conversation. From this perspective, what we call a representation is not a correspondence given an external state of affairs, but rather a consistency with its own ongoing maintenance of identity. Such regularities, which we choose to call symbolic, are not operational for the system, for it is we who are establishing the correspondence from a vantage point that is not in the system's operation. Thus, when we switch from a control to an autonomy perspective, what we call information differs from the computer gestalt in important ways. Every bit of information is relative to the maintenance of a system's identity, and can only be described in reference to it, for there is no designer. In this sense information is never picked up or transferred, nor is there any difference whatsoever between informational and non-informational entities in a system's ambient. ' <Varela: *Op. Cit.*, p xiv>

As listed above, the first component that is required for the construction of a learning environment that is cybernetically based is that of an embodiment of an expert model that will encompass conceptual skills of all kinds. Heinz provides us with a basis of Eigen functions and Eigen values as models of concepts. The convergences of values in Eigen functions, and their persistence as stable Eigen values, are useful models of the formulation and retention, respectively, of mental processes. So we begin with concepts represented as processes, interacting with other processes (alias concepts) and stabilizing to fixed points that are not points at all, but multi-dimensional areas that are collections, which, when executed or applied, reproduce the concept in one or many ways.

Relationships among concepts can (and do) formulate new concepts. These combinations of concepts are the essence of the evolution of concepts in a mental repertoire, and hence are the key to learning. Just as the keyboard skill can be considered a combination of simple skills leading to complex ones (in a process that is the opposite of simplification), conceptual skills can be considered as composed, at least temporarily, of simpler concepts that make up 'more

complex' ones. But the attribution of simple and complex comes from the observer, whereas there is no such order or hierarchy or control in the closed system of concepts (surely you realized they too would be modeled as closed, autonomous systems of circular causality?).

Conceptual skills are usefully considered as composed of simpler ones only temporarily, because 'interpretation' does lead to understanding the meaning: it is the meaning, composed by a circle or cycle of interpretation, that is the closure and hence the autonomy of concepts. This is the basis of what is called hermeneutics, a term that existed long before the coining of second-order cybernetics but fully consistent with it. As you will see, the hermeneutic cycle of interpretation has a modern manifestation in the modeling of the micro-structure of concepts, for the sake of preserving their attributes while captured in a mechanical interface, for the purpose of mediation between human and human.

Now I will offer an example of a relation in a mental repertoire. What follows is isolated from the normally tangled morass, to minimize straggling component parts that would merely litter the example. Therefore it is an impossible situation, for nothing stands alone in the mental repertoire: all things interconnect with all others, somehow. *{He begins to draw what becomes will become Figure 16.}* Consider water and the act of drinking.

After Gordon's terminology I will call these elemental objects, these nodes of a database, 'topics.' When they exist in a mental repertoire they are not objects, per se, but processes that we model as Eigen functions... and so forth, I will stop being tedious about reminding you of the meanings in my context, I promise; I hope.

*{He steps forward once again, away from the projector, and continues, with an intimate tone.}*

Forgive me. Without your active help, I of course would be doomed to such distinction-making, such repetition, such continual defining of what is behind what of I speak [sic]. You hold in memory what I have said, make connections, reference your own experience. Thank you.

*{Conciliatory}* Without your help nothing I say has meaning. I require you: to make myself; you ingest (another body metaphor to reify a metaphorical world) my expression of thoughts and to combine them to live again. My flesh moves before you, but the fragments of mind that you receive in sights and sounds are inert. You make my ideas live, again.

*{Needing}* Without your help nothing I say has meaning --- to either of us, because meaning is that which is shared, agreed, wallowed in together. This result may seem astonishing, but I could not even make 'my own' meanings without the context of the knowing and language and so the living together that is present around me. My inside is outside and vice versa, and yours is too.

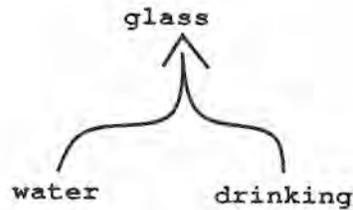
*{Recovering}* I also need your help in preserving the true structure of all that I say. Writing these words down does not suffice; our time and space must be locked together, synchronized, for you to know me. Forced to present myself here before you, you must hear and see in linear time, though my thoughts and yours could not exist in so trivial a form. And --- I am thankful for the constraint of linear time, for only therein may I bring my own self to you: for, in each moment, each choice is mine to make. And so, here I am.

*{Returning to the podium}:*

So let me... *{turning to the audience}* will you?... *{seeing cooperation, he is pleased}* let me use a simple example. Remember ... yes? ... topics are the result of the execution of Eigen functions. So 'execution' of a concept repertoire 'produces' topics. And so, when we combine topics, here water and drinking, we might realize that this produces (among many possible productions) the

topic of 'glass.' Note that the context of the production brings to our minds, as observers, the type of glass that holds water and is used for drinking. Other types of 'glass' and 'glasses' also exist (such as the substance that melts when heated, or is in windows, or what hovers on the nose to aid the eyesight of Mr Palomar). The production is clear however.

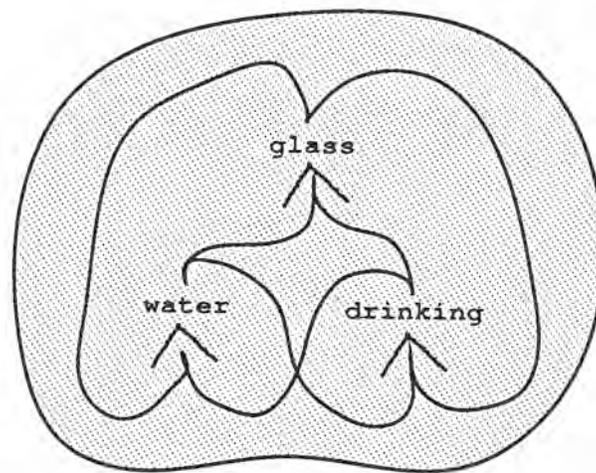
Figure 16.



Now combine the topics of 'glass' and 'water' {he points at the figure to show the direction of production}. If we had this experience in our mental repertoire, it would be very simple to generate the topic 'drinking' from the other two. And not unexpectedly the topic 'water' could just as easily be generated from 'glass' and 'drinking' in the same manner of production {pointing again}.

All of these combinations together form a unity comprised of the dance among these three topics. Pask would call this dance a 'concept.' Fulfillment of the constraint that all possible productions exist and that the entire grouping is a closed organization, produces a 'coherence.' {He draws a bubble around the topics in the Figure 16, which is now complete as Figure 17.}

Figure 17.



One elegance {sic} of the theory is the analogy of the closure of an organism and the closure of mental events.

{Pangaro pauses to consider whether the above presentation is too simplified; specifically, the figures leave out an essential point, that the topics are not merely placeholders for processes, but for complementary pairs of processes. There is a descriptive part, which tends to be implied by the naming of the topic itself, but is more than the naming; and there is also a prescriptive part that specifies how the topic interacts in a dynamic with the other topics of the relation under consideration. Löfgren would also make an excellent reference here, with his concept of linguistic complementarity: that language

contains descriptions and interpretations that are complementary within the language. <Lofgren: Op. Cit., p 11> The full equations, whether from Löfgren or Pask, are rather beyond what is easily conveyed in a lecture/performance situation, however, and he decides only to make the following remark.}

Pangaro: I must point out that I am simplifying the matter somewhat; for example, the topic name and the topic that is the process are not the same thing. Writing the topic name as a placeholder should not allow us to forget that topics are, at least, complementary pairs consisting of descriptive and prescriptive components which together model the topic. A descriptive component is, for example, 'a glass is designed to hold water while drinking'; a prescriptive component might be the actual procedure for demonstrating that effect.

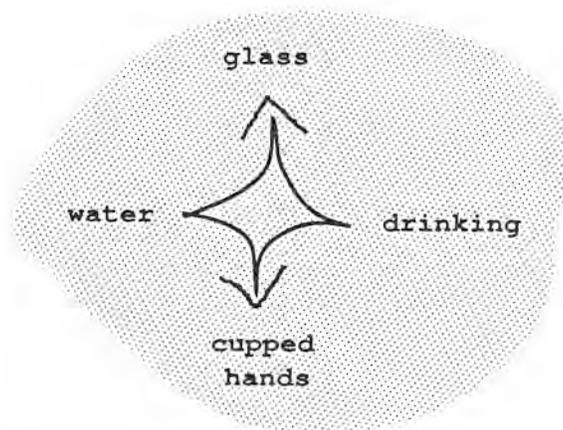
{He drinks from his glass of water once again, without comment. Pause.}

Here's another subtlety I don't want to skip over. Whenever Gordon talks about these things he always emphasizes that a topic is a repertoire of processes that are consonant, or conflict-free, with one another. I like to think of lots of processes buzzing along merrily --- think about all the cups you've ever seen in your life, quickly, as quickly as you can, think of all of them. If you have trouble doing this, think about the first cup you ever saw, and then the next few, maybe a set at home when you were a child, {rushing ahead with the words} and then think of them all up to today's cup of morning tea. These all make sense together; they are all cups; so you have a coherent set, a repertoire of ways of thinking about cups --- but wait, there was that one that didn't have a handle because it was by a wacko designer from South America. But there, you see, that took some special processing, you had to be conscious of the difference and similarity and have short conversation with yourself about it.

Back to our diagram. A frequent objection at this point, and I can hear it in some of your minds, is that many more things than 'water' might be generated from 'glass' and 'drinking.' This is, of course, very reasonable --- but that would require more information than we have at present, because we stipulated that we would examine only a small part of a complete repertoire. Let's talk about expanding the repertoire with new topics.

I might for example offer a new topic named 'cupped hands' that I demonstrate to you by moving my hands together to form a cup (its descriptive component). I can then also actually use it for 'drinking' 'water' (a prescriptive component) and thereby produce a new relationship {which he draws as Figure 18}.

Figure 18.



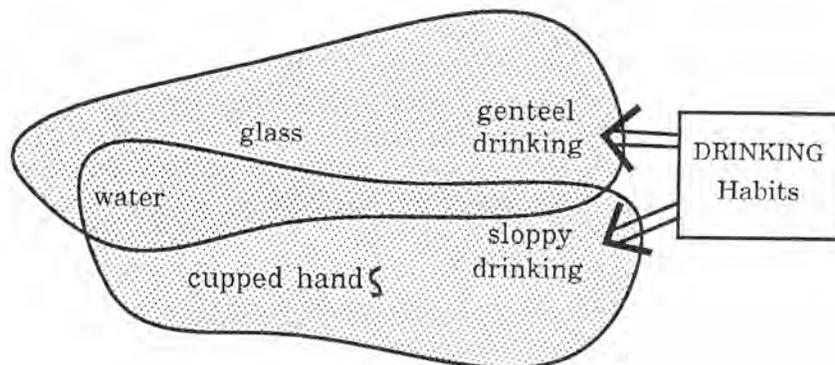
If we have taken these rules of production seriously, and still within the limitation that we are considering only a very tiny and bounded portion of a model of concepts, we have a serious problem here, one that solves itself in a kind of revelation. Ask a question of this structure, of the form, 'If I combine the topics 'drinking' and 'water', what do I produce?' Remember that this is a valid question because the relations in the figure as drawn by arrows here *mean* 'produce' and 're-produce.' So it is valid to assert that the figure indicates that two possible topics are produced, 'cupped hands' and / or / either / maybe / both 'glass.' From the figure itself there is no apparent reason why there is any difference between 'cupped hands' and 'glass.' Now you and I as external observers know clearly that these are different things, different topics, because we can interpret their names as more than merely placeholders and fill in a world of interpretations (alias descriptive and prescriptive components) that keep these two topics distinct. But the structure itself has no such information contained in it; hence, there is a potential conflict / contradiction / ambiguity if the structure were to be left as it is.

You might even say there is a resonance of flipping back and forth between the two possible stable interpretations, and you might hypothesize that this resonance is equivalent to a 'call for information', for a modification of the structure or a call for further distinction, to stabilize and encompass all topics within a structure that is sufficient to hold it all 'coherently.'

The structure can be stabilized in a number of ways (that must be covered in another presentation, another occasion together, to cover the issues of where the information comes from, how it is integrated, and so forth) <Pask, Gordon, *Developments in Conversation Theory, Part I, International Journal of Man-Machine Studies, Volume 13, 1980, pp. 357-411*>. The first case which should be mentioned for completeness, is that these two, apparently differently-named topics {*he points at 'cupped hands' and 'glass'*} are in fact the same; one can imagine a mistake of this kind made where the names are distinct but the topic itself is not, a case where two different topic *names* mean the same thing; a case of synonyms, in other words. Of course this is not appropriate here.

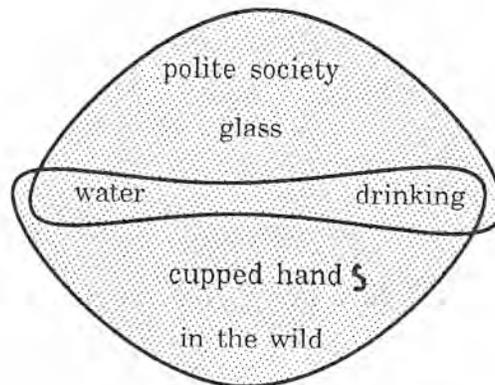
The second case, again mentioned for completeness, is that this topic {*he points at 'drinking'*} should actually be split into two topics: there are, perhaps, two types of drinking that we wish to distinguish to encompass the new topic of 'cupped hands.' Of course the split may involve a renaming, to 'genteel drinking' (with the glass) and 'sloppy drinking' (with cupped hands). This has the effect of adding distinction by splitting an existing topic --- a bifurcation, in other words, where a topic splits into distinct parts. 'Water' might also be split but you may agree this is less sensible, because indeed the type of water is the same in both cases. Here is the result {*showing Figure 19*}.

Figure 19.



Another means of resolving the conflict is to add additional topics into both halves, into each relation. 'In the wild' might be added here {showing Figure 20} and 'polite society' to the other.

Figure 20.



These proposals make for a very fast look at a process that underlies the evolution of mental structures alias learning, a topic that is very much before us as we proceed.

As always in our cybernetic dealings we want to be clear about who is doing the distinguishing in our example; *who* is adding the information that is called for. In these examples the system under study has its internal closure (at least that is what we are striving for, to ensure coherence and autonomy and hence stability and persistence, all in a description that keeps the observers outside and the participants inside --- for the moment). Clearly we have been external observers, viewing the system 'from above', as it were. Thus far we have a model that attempts to describe cognitive events but its validity is diminished because it cannot be used to describe how such systems perform these acts of distinction and evolution within themselves. Calling for information to be obtained from outside the system is one thing, and it must play a part; but there is a clear distinction between that and 'internal' changes occurring because of further internal 'processing.'

Can we simulate the internal detection of conflict? The answer is yes, and the means to it are very simple. Imagine that we represent each of the processes that a topic is, as an individual node, an actor. (Now remember (1) that the thing we call a topic is a placeholder for a process repertoire; and (2) what we are about to describe is a metaphor and simulation of what occurs in some dance of processes where the nodes we speak of merely mean stabilities: the *endurance* of specific processes.)

What is each topic in touch with? The other topics it interacts with directly. How does it interact? Productively, in that the result of the interaction continues to reproduce each individual topic in a coherence. We might interpret this production as having two aspects:

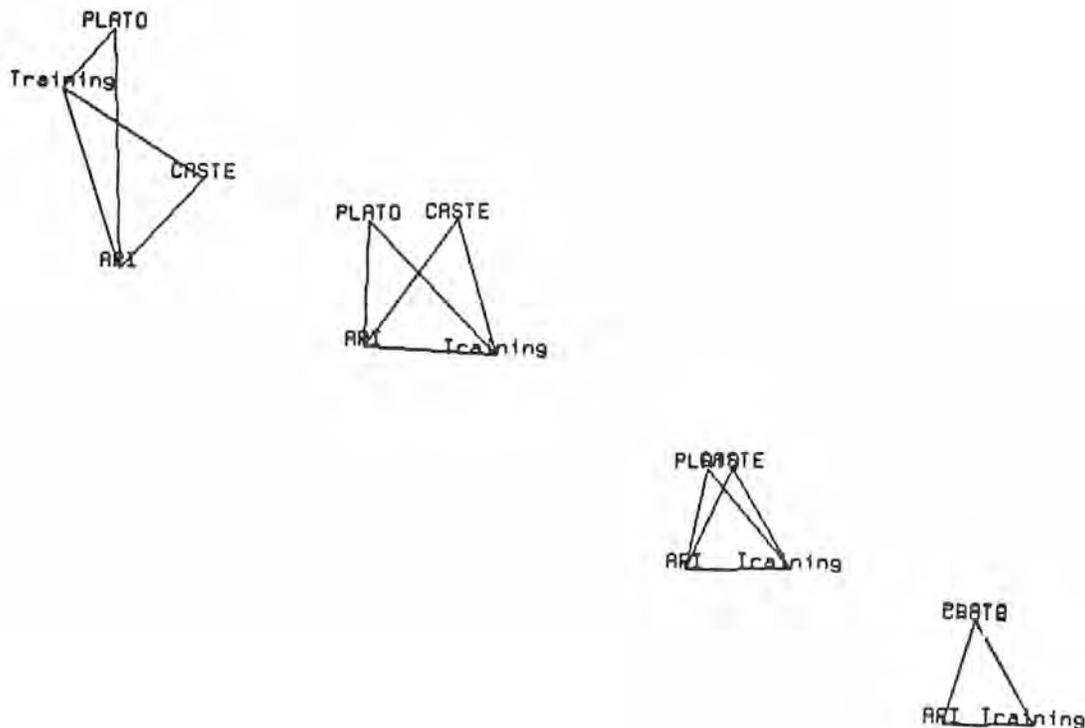
1. distinction-generation, where the individual topics as produced are clearly distinct from each other;
2. neighborhood-generation, where the individual topics adhere to the same, mutually-made neighborhood because their interaction produces them and hence the interaction really is their neighborhood.

So each topic, were it to have a perspective of its own, is both repelled (in that it is made distinct), and attracted (in that it is produced from its neighbors) and both these simultaneously. It was this chain of metaphorical reasoning that led me, in a somewhat excited state, to write a software simulation on a first-generation microcomputer in the programming language BASIC. This machine, called the PET, was installed in the den of epistemology of Gordon's flat in Richmond, a little ways outside of London, amidst miniature stuffed alligators, and adjacent to piles of old journals and used pipe tobacco (leading to many analogical similarities in my mind).

Too slow to produce dynamic animations, the machine still showed that the calculations, simple as they were and consistent with the internal system view, could compute conflict.

I gave up the metaphysician's den for a super-minicomputer called the Symbolics, for its support of truly 'rapid prototyping' capabilities. The results were very exciting in their real-time dance, and became the core of my doctoral dissertation. By demonstrating how a system can compute distinction within its own structure, I was able to confirm the predictions of the macro theory of conversations, in the micro realm of process and coherence. <Pangaro, Paul A.: "An Examination and Confirmation of a Macro Theory of Conversation through A Realization of the Protologic Lp by Microscopic Simulation", Ph.D. Thesis, Department of Cybernetics, Brunel University, May 1987> This figure {placing Figure 21 on the overhead projector} shows a slice of one such sequence (the static figure does not do justice to the dynamic animation) of how a complex structure can emerge into distinct topics, with neighborhoods represented as lines between.

Figure 21.



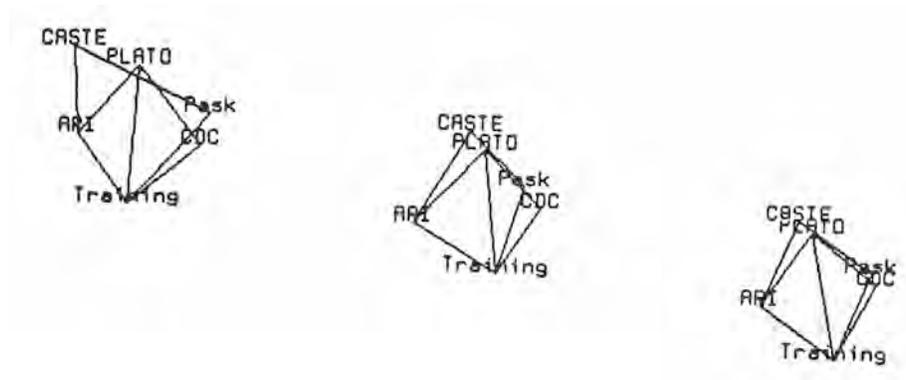
I show a specific case that can be understood, if we give meaning to each topic: One assertion, represented by the triangle neighborhood, has the meaning 'The PLATO system is used by ARI to do Training', the ARI being the Army Research Institute, this latter assertion being left out of this figure for simplicities' sake, but I tell you here to help make some sense of it. The second triangle says, in effect, 'The CASTE system is used by ARI to do Training,' CASTE being a system designed and built by Gordon in the 1960s as a successor to Musicolour and SAKI, to exercise conceptual skills in a similar closed loop as before.

Now, invoking perspectives from the outside (as we did above when drinking water) we ask the question, what does ARI use for training? There is insufficient distinction in this structure to distinguish between PLATO and CASTE. But we can also ask the same of the abstract structure without regard for the values that these topics (alias processes) actually have. At that level of description, merely as nodes in a neighborhood with forces acting on them, they can attract their neighbors and repel those they are distinct from. And *viola*: the mental topology is such that {pointing to each successive sub-part of the Figure, and then to the blotch where CASTE and PLATO occupy the same spot} these two topics cannot be distinguished.

{He pauses.}

Adding further distinctions, say that CASTE is from Pask and PLATO from the company CDC, provides a similar dance {passing his pointer to successive images in Figure 22}. The result is that CASTE and PLATO are, in fact, distinct, but not so distinct as the other topics that maintain a greater distance.

Figure 22.



These closures are themselves a 'through looping'; each process (alias topic) can be said to 'loop through' its neighbors, all of them at once, and then 'come out the other end' --- which is really the spot we started from --- just as we as organisms 'loop through' our total environment and come out at the other end, reproduced by the processes of our environment. We exist in that exquisite complementarity, we are both made and making, by and in, the environment that we call the 'world.'

The mental aggregates that we ourselves compose and are composed of are vastly greater in extent and structure than these, truly trivial, examples. Once the structures under study become complex, one needs a software engine to aid in their manipulation. Just such a system is that called THOUGHTSTICKER, a title that can be taken as a generic, referring to any software system that utilizes Pask's knowledge structures of topics, coherences, analogies and so forth,

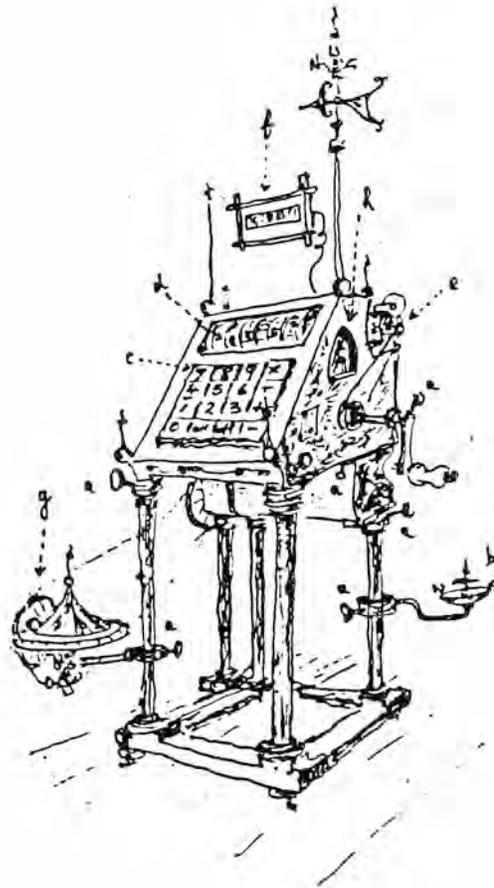
for the purpose of representing, manipulating, or conveying information between individuals. My own version has been constructed, also on the Symbolics, with the help of Jeffrey Nicoll as co-designer and -developer, funded by a myriad of sponsors starting in 1981.

THOUGHTSTICKER is fully prepared to take in, store, and recapitulate very complex knowledge structures, and its means for conveying them to users (alias learners or operators) are quite well developed. It has also been the experimental environment for extending the Paskian approach, specifically features to aid the process of conflict resolution by suggesting specific resolutions in particular cases, and in being able to handle multiple authors. <The most accessible description of the Symbolics-based version is in Pangaro, Paul, 'THOUGHTSTICKER: An Idiosyncratic History of Conversation Theory in Software, and its Progenitor, Gordon Pask, *Kybernetes*, Volume 30, Number 5/6, 2001 >

Let me show you precisely what sort of technology has and will be used for the development of THOUGHTSTICKER, and indeed, all software-based computation of the late 20th century and some unfortunate part of the 21st. I guarantee you that the machine I am about to display is the most advanced, sophisticated, and state-of-the-art machine available, bar none.

*{With great flourish he replaces the overhead with that of Figure 23. Short pause until reaction.}*

Figure 23.



Handwritten notes:  $f_3 f_3$  Caption Useful display of results (d)

Our machine, the "Eureka", supplied also with Corinthian and Ionic supporting pillars. If dismantled by removing all thumbscrews (a) fits easily into pockets. Compass (b) as required for navigation. Keyboard (c) for numbers (0 to 9) and operations (+ - \* /). Useful display of results (d). Electric motor to aid manual crank action (e) with starting capacitor or. Advanced design reflected in auxiliary solid-state display (f) and integral random number generator (g) may be scrutinised through inspection port (h). Weather vane atop the equipment provides better and independent source of random numbers.

Handwritten note: Provides better and independent source of random numbers

Pangaro {reading the caption, indicating the scrawled and undecipherable words as he does so}:

'Our machine, the "Eureka", supplied also with Corinthian and Ionic supporting pillars. If dismantled by removing all thumbscrews (a) {pointing to various examples of the 'a' in the figure} fits easily into pockets. {Pause.} Compass (b) as required for navigation. Keyboard (c) for numbers (0 to 9) and operations (+ - \* /). {Pointing off to the side, where this addition to the caption was made..} Useful display of results (d). {Then.} Electric motor to aid manual crank action (e) with starting capacitor or. Advanced design reflected in auxiliary solid-state display (f) and integral random number generator (g) may be scrutinised through inspection port (h). Weather vane atop the equipment provides better and independent source of random numbers.'

This satirical conceit has a serious point: compared to the processes just described (the interpenetration of processes that are concepts in a mental repertoire), our calculating engines are far behind. For no machine now available, whether networked or stand-alone, parallel or

mega-serial, is fundamentally different than our Eureka. Of course we have faster machines; larger capacity machines. Even our Eureka does not stand still and was recently upgraded. {placing Figure 24 the overhead}.

Figure 24.



Here we have the desktop model. {He again waits, but less time, for a reaction.} Notice the Turing tape, used for programmability; the phone, and its input/output buffers, for communication; and of course the desk. (When I asked Gordon to update the Eureka I had no sense the upgrade would be so modernizing. When I asked him to comment on the improved facilities of this new model, he replied, with unguarded disdain, 'Well, of course the desktop version comes with a desk.') But all modern computers, including our little Eureka, are subject to the same constraints, imposed by the world view that seeks to consider input and output, I-to-I representations of primary importance.

Recent mega-parallel machines, of which the Connection Machine is the most well known, may someday demonstrate the capability to reach beyond the limits of serial, digital computation. <W. Daniel Hillis: *The connection machine*, MIT Press, Cambridge, Massachusetts, 1985> But to date they have been used as merely parallel versions of our Eureka. When serial or parallel processors conflict we say there are problems in the communication bus or software threads, and consider the system broken. Concurrency, in which conflict occurs and is resolved within a myriad of interpenetrating processes, is something else again. To see an embodiment of Gordon's logic of coherence, distinction, and process would be a revelation, I think.

'Connectionist' styles of programming may be closer, in which the 'inside' representations are not (necessarily) symbolic and the data values exist as process states rather than static binary configurations in a storage cell. But even neural net approaches can embody the same distortions of AI and cognitive science in their search for internal, symbolic representations of 'external' objects. <For a major report of research on connectionist approaches that nonetheless embody the conventional quests of AI and cognitive psychology, see Rumelhart, David E., and McClelland, James L. and the PDP Research Group: *Parallel Distributed Processing, Explorations in the Micro-Structure of Cognition*, MIT Press, Cambridge, Massachusetts, 1986> Much can be accomplished within these distortions, as the history of computation engineering attests, and much cannot, as our theory shows. The hardware or software technique alone do not impose epistemological constraints as much as the current fashion does.

Within or without the present fashions in software engineering, there is more that can be said about both THOUGHTSTICKER and its underlying techniques. For example, it can be shown that given a rich set of related topics, new analogies can be proposed from inside the system, in a kind of innovating that takes place internal to the system, just as conflict detection can be internal. But these topics are themselves too complex to enter into here, as they are more the realms of research than of performance. Instead we recapitulate some ideas, in preparation for describing the structural relation among autonomous individuals, in the case where my environment is you and vice versa.

## 19. Interaction: The Architecture of Language

Pangaro: Where might we all be going together on this vast excursion? In more than one direction at once:

- sketching the history of cybernetics and its instantaneous transition from control theory to epistemology
- showing a revision that cybernetics affords the notions of reality, objectivity and knowledge
- implying what might change at the foundations of AI in order to utilize these insights for the benefit of the human use of mechanical beings.

Interaction is key:

- Occurring between observer and observed, interaction is the primitive from which arises what-can-be-known.
- Occurring about *[sic]* the exchange across participants in a conversation, interaction creates and is created by the distinction between participants.
- The observer computes the interaction; complementarity-wise, the interaction computes the observer. Neither would exist without the other.
- Not merely passive, observers are participants --- in a particular sense, that they themselves have direct impact on what they see, on how they observe.
- When there is a reflexive interaction (observers are also the observed in a symmetric relation), what-can-be-known is relative to a participant-observer's point of view.

And, we need to add these points to the brew:

- Embrace of these basics in turn requires a method of enquiry consistent with it.
- Cybernetics, as the science (the 'objective') of interaction (the 'subjective'), itself exists as a 'when' not a 'what.'

What can be objective when all is subjective and constructed? There may appear to be two separate cases: where the interaction is between organizations that have distinct physical differences (plaintiff and defendant; different schools of thought); and where the interaction is within a single organization (schizophrenic; or me, myself, and I). This latter, 'psychological' case in fact has the same structural aspects: as observers we cannot get inside the view of either side, any more than we could get into the belief structure of any other argument or agreement. Unless of course we were part of one side or the other; then of course we would lose our 'objectivity' as outsiders to the interaction. But in another, larger context we are both objective (we can view ourselves interacting) and subjective (we believe what we believe on our side of the dialog --- even if it be one side at a time!).

What structure, or architecture, of interaction might encompass all this usefully? And where might it be applied?

Taking applications first, one is that of science. We have seen (or rather, I have tried to show) how Chicho's four points on scientific enquiry are a valid model of that highly specialized, but nonetheless human process of enquiry. I (or rather, we) do not need 'reality' to do science, although it would appear that the very existence of science is predicated on it. Whether we accept, or whether there is reality becomes a thought experiment only and not a determinant of scientific results. Perhaps --- and I'm incapable of debating this one very far --- some consistencies that we derive from experience do emanate from the physical components of 'the world' but we do not have access to these except through our subjective perceptions. Objectivity does not come from an external world. Instead we must accept agreement as the objectivity --- 'objectivity in parenthesis' as Chicho would call it, which I (can only) paraphrase and interpret to mean that objectivity must be qualified, contextualized.

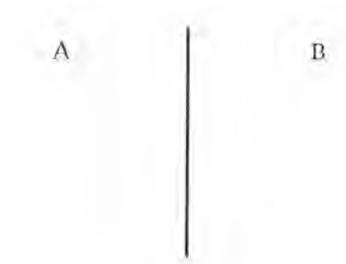
But outside of rarified science, how do we operate? It seems that there is created (who does the creating?) a myth of objectivity. We pretend that objects exist, a world exists, though we can never confirm this independent of ourselves --- for *all* of our knowing is in terms of our self[sic].

This pretending is a form of agreement, and if we did not agree (or act as if we agree) then we could neither interact with others nor operate on our own in the world --- as if we could learn to do the latter without first having the former. And this macro-level of operation is supported by every-day, micro-level agreement: this is a table, this is not a table; I am thirsty, please pass the water. {*He gestures as if to, but does not take, the glass of water.*}

But how does this agreement, macro and micro, arise? What are its mechanics such that we could describe it, model it to our benefit? And indeed, what benefits might there be?

To have an interaction there must be a distinction drawn between two (or more) entities who are seen to interact --- seen by an observer, and indeed all of our comments, as always (when cybernetic) are from this posture {*he draws a vertical cleft, beginning what will become Figure 25*}.

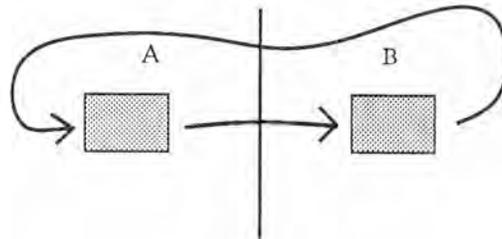
Figure 25.



Let us call these entities P-individuals, consistent with Gordon's term to refer to psychological individuals. <Pask, Gordon: *Conversation, Cognition and Learning*, Elsevier, Amsterdam, 1975> They are different from persons because one person has many such perspectives (and we often have conversations with ourselves in just this way). {*He pauses as if talking to himself to settle the question as to whether this really happens. He concludes internally that it does, and again addresses the audience.*} Right.

We will name our P-individuals A and B, and draw a box inside them to represent repertoires of procedures --- which you will recognize as part of our earlier discussion of stable, interacting topics and their relations, making up productive and reproductive closures. And finally let us say that the interaction between them, their discourse, takes place in some language called L. This language must be capable of commands and questions, as well as statements and predications (these being special cases, for to make a simple statement is to ask to be believed). I can represent this interaction as follows {*Figure 26*}.

Figure 26.



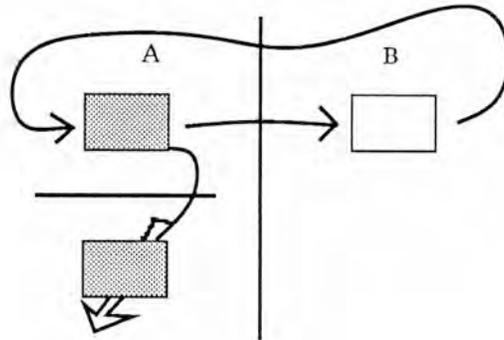
{*Pangaro draws a line from A to B across the vertical cleft and then beyond, looping above and back across the cleft and into A again. He walks away from the projector slightly to make the next point.*}

Now I expect that the significance of these loops will not be lost on you. I could not have drawn them any other way, nor could I have drawn them until I had told you what I have already said today about looping. {*He smiles.*} This is not a drawing about input/output, nor about systems that are *claimed* to be {*he says it like it is distasteful*} 'interactive.'

{*Moving back to the projector*} Now in addition to this vertical distinction between P-individuals it is also useful for the observer to make a horizontal distinction, to divide the mental repertoires into levels or hierarchies {*drawing a line below the box on side A, in what becomes Figure 27*}. One way of thinking of such a division, though not the only one, is the distinction between a 'goal' and an 'action' to be taken. Sometimes this action can be something that takes place in the physical world, such as walking across the room {*he lurches off suddenly as if he is taking such an action*}. Or it may be a sub-goal, a means to the end of achieving the goal that doesn't quite seem like an action in the world; a 'method', so to say, of achieving the goal.

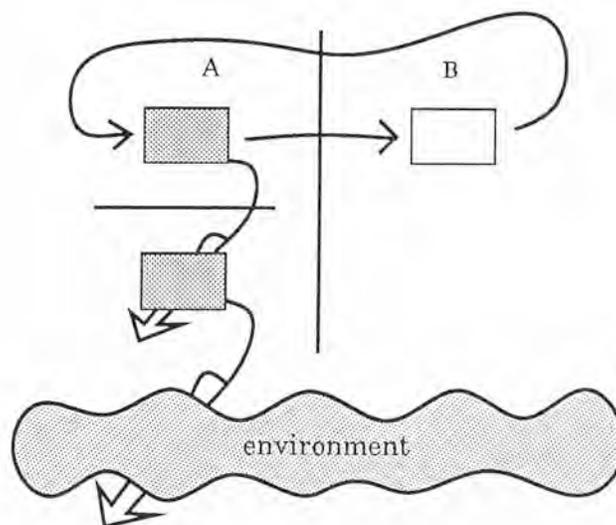
Let's work through an example. Say the goal to be represented in the mental repertoire of A is to 'drink some water.' This takes place at a higher level to the method to achieve the goal, and there are many such methods that can be chosen: get a glass, fill it with water, drink it; ask your waiter for some water, take it, drink it; or, open your mouth in the rain. I can represent the relationship between the goal and the method by drawing a link, like this {he does so} where the double arrow going into the method level indicates a causal link: that set of mental processes does not have any choice as to how to act. It is taken by the throat, as it were, and it responds by executing the method to achieve the goal dictated by the level above it.

Figure 27.



The 'method' level responds, as it must, by determining a method to execute and by controlling in turn a level lower than it --- eventually the world itself, which of course must also (relative to what I am calling here the method level) respond without choice. Water glasses do not have a choice, after all. {He takes a quick drink.} So the visual language is consistent, and we draw a causal arrow {he does so} below, and the environment thus.

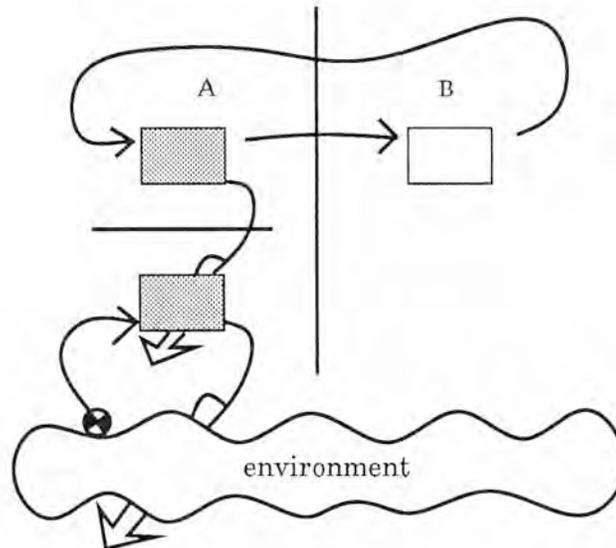
{Figure 28.}



It is worth commenting that 'the world' is simply a metaphor for what is beyond our bodies, where this distinction is not perfectly known. Further, any level below a 'method' level is an environment to that level; it may very well still be in the domain of mentation.

The result of execution is then available to our perceptions: if I have obtained a glass, and I fill it and drink from it, we can say that this is a feedback from this level *{pointing to the environment}* to this *{the 'method' level}*. I will draw it as follows *{he draws a line back up from the environment, from a half-filled circle at the environment level in what becomes Figure 29}*.

Figure 29.



Having returned this data to the higher level, the question can be asked: did I achieve my goal? Well, notice I have tricked you, because relative to this level *{the environment}*, this level *{'method'}* is a 'goal' level: the goal was to take a glass filled with water and drink it. And that has been achieved, so this is a closed loop, yes, a closure, and it is a stable interaction of processes.

Another way to think about this closure is to again realize that a topic is a complementary pair of descriptive and prescriptive parts. The descriptive part is up here *{pointing to the 'method' level}*, and the prescriptive is down here *{pointing to the level of the environment}*. So the closure across these levels is like the closure of a coherence, but with the emphasis on the dimension of complementary pairs, rather than the inter-reproduction of each topic in the neighborhood (where these two dimensions are themselves complementary!)

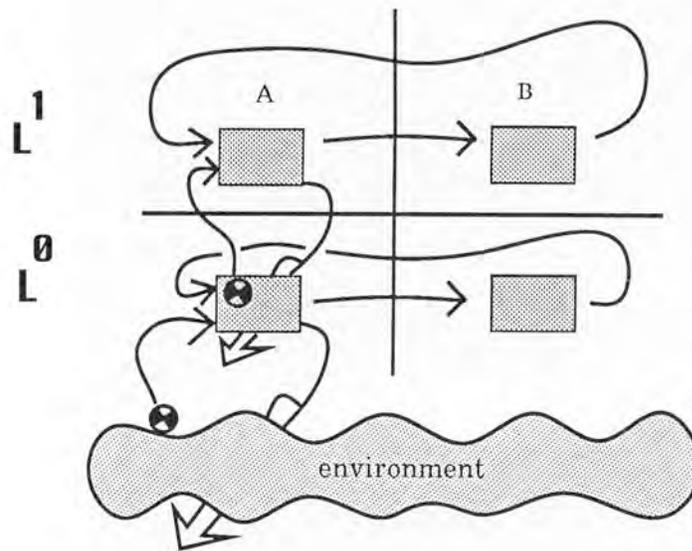
We can also move the next level up: we can return the results of whether we have gotten a glass, etc., (and we have), up to the next level *{drawing Figure 30}*, where the question is whether we have drunk some water --- and we have. So this too *{pointing}* is a closure, is stable, and now we have learned something *{circling up and down the entire A side of the diagram, as if the completion of the closure is the learning}*.



Thankfully there is a point beyond which our shared context (the room we are in, our culture, our human-ness) makes it unnecessary to go any further with this.

Just as the levels can be said to exist within an organization (a P-individual) we can make distinctions in the levels of discourse that occur between an A and a B. We say there are commands or questions at the level of 'help me drink some water' {pointing to the existing loop} or {drawing another level of loop from A to B, and then adding the box on the B side at the lower level, for what becomes Figure 32} on the level of 'help me to get a glass, fill it with water...' etc.

Figure 32.



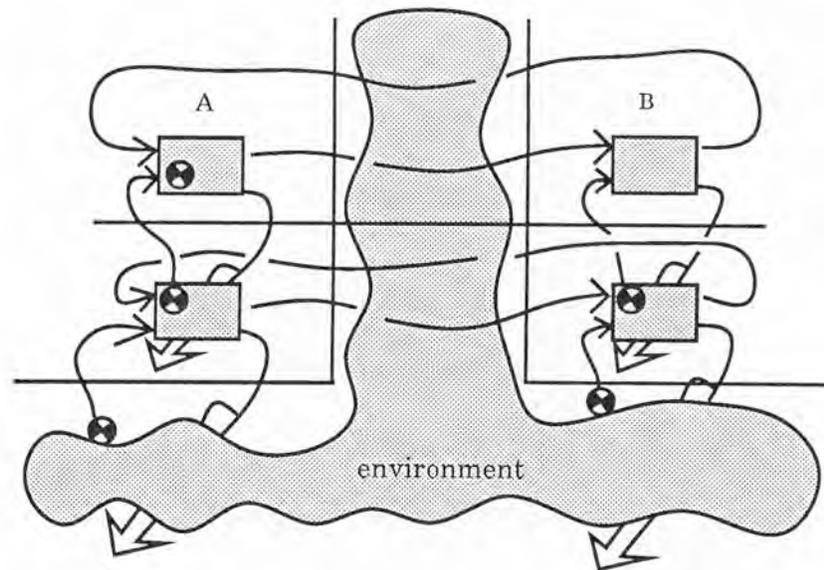
Now it may seem to be a fudge to break up the processes in just this way, but I assure you that you can divide them as you like --- after all it is an observer statement to assert where the levels are. This is no backing off the problem [sic], but a reminder of the subjective quality of the entire modeling process. We just as arbitrarily call these exchanges in L to be in L<sup>1</sup> at the 'goal' level and L<sup>0</sup> at the 'method' level --- where these attributions of goal and method are sliding, and always maintained in relation to each other.

When we have the control lines running vertically, the higher level treats the lower one just that way: as higher, hierarchically. The lower level has no choice in the matter, it must respond. Consider the command to your arm to carry out the method of filling the water glass: the arm cannot very well say, 'Gee, no thanks, I won't help you today.' In this sense these transactions treat the lower level like an 'it'; or we can speak fancy [sic] and call the transactions 'it-referenced.'

Such physical manifestations take place of course in the environment; so also do the transactions of language, which require (in nearly all cases, except those of clairvoyance, alias synchronization) some physical form to join us, to bring us together to share. (Chicho calls language the actions of 'living together.')

So the Figure should be amended to include the environment, thus {he produces Figure 33, showing the environment as the medium in which language transactions occur}.

Figure 33.



This environment may be merely the presence of A and B in the same room; or in the same head. It may be made by the telegraph or telephone, and may be across time as well as space, in that the transactions may be started and finished across days; years; cultures.

These transactions across the vertical divide are subjective, in that they are from the position of a participant who does not have direct access to the internal repertoire of the 'other.' This is in contrast to transactions across the horizontal divide (the up/down ones), which do not require a point of view exchanged, or the taking on of another's topics and the interpretation of them -- - therefore these vertical transactions are 'objective' in that there is no interpretation allowed, only the actions required by the (higher) controlling process. So we appear to have an architecture in which objective and subjective transactions can co-exist.

A question remains, that of status of the observer of this entire architecture of interchange. Remember that our position as observers of this entire process places us (by definition) on the outside of the transaction; we do not participate in it, take on the beliefs, accept the goals, etc. In this sense, we take an 'objective' stance --- in fact, what we represent or objectify is the degree of 'agreement' between (or among more than two of) these perspectives. Of course, both A and B must exteriorize enough of their  $L^1$  and  $L^0$  repertoires so that we can observe that they do 'match' or 'fit' each other --- or are coherent --- and hence manifest the existence of otherwise internal, stable mental procedures.

## 20. Selves as Observers

Pangaro: But who takes the stance of observer? Sometimes, the participants, the A and the B, do. We, for example, you and I, are engaged in a discussion --- we talk, we ask, explain, interrupt, and on many levels. Then, you may say 'I agree with you' --- which is represented in our diagrams by you taking the stance of observer. You stand aside, as it were, and consider what we have inter-changed:

- we seem to have the same goal or goals;
- we seem to have the same methods for achieving them.

I say 'seem' because you cannot see into the little boxes inside of me. And vice-versa. All you can have known to make your judgment is what I exteriorize in 'the course of dis-course' [sic] {*an aside:*} (sorry). What I have given out into the environment, which is between and among us, is all you have to judge with. Hence the importance of your participation as B in the discourse, to confirm antecedents, check meanings of terms, ask for further details, and so forth --- it is all you have.

One of the advantages of the architecture of conversation as presented by Pask in his 'Conversation Theory' (for that is what I have been describing, albeit in my own words) is that we can now specify in full detail a structure or 'framework for understanding understanding.' In addition to the inter-changes noted above, we also need to confirm that they constitute a closure. We do this in only one way: by becoming 'the other' sufficiently to check that the levels couple and cohere and reach closure. We must accept the transactions on  $L^1$  and some corresponding ones on  $L^0$ . These are the familiar, horizontal loops, now carrying some artifact of A's internal repertoire over to B. It is B's responsibility, however, to make connections internal to his or herself to ensure that some closure is found, completing the vertical transactions within the integrity that is B. This is not hard to do, in that the hardware/software of the organism is geared toward achieving such closure --- indeed it seems to be the primary energy of any intelligent life. Notice this is another way to express the subjectivity of experience --- even what you tell me I have to make my own to know you.

So too must you do the same for what I express to you: you must 'put it together', as the popular expression goes. You do this of course without access to my further, 'higher' levels of intention: what goes on at  $L^2$ ,  $L^3$ , and so forth. Sometimes though you do ask for clarification about those higher levels: 'What is the point here?' Or, you need lower levels: 'What do you mean? Can you give me an example? Can you explain that *please?* (and where the politeness is sometimes necessary). Most often, though, a present context, the common culture and our biological origins allow for understanding without so much backing-and-forthing as to frustrate and prevent enough 'connection' to be satisfying. (Notice that this is the very problem with human/computer interaction: there is no *a priori* shared context or experience, and hence every detailed step must be given, tediously. Without the confirming, stabilizing closure of multiple levels of conversation and description, so much can go wrong.)

Of course what is shared is in one way 'less' than what is on each side: you can never know all the ways in which I 'know' something, and so too vice versa. Hence what is shared and understood is what overlaps in our, from our, conceptual repertoires.

Now, insofar as *what* we agree on (the 'why' and 'how', the  $L^1$  and  $L^0$ ) is specified outside ourselves, in some environment that can be witnessed by an observer (who may be us), our 'agreement over an understanding' can be verified. That's right, we can *demonstrate and measure* our agreement to the degree we have the patience to specify details of our internal repertoires at various levels of L (at least 2 levels that are coupled by closure). We do not need to witness the internal closures directly (and we cannot anyhow). We only require that both A and B have absorbed the other's topics and relations, and that they each indicate that the other's closure (make up of topics and relations) produces something that they recognize (something that fits, I can relate to) as consistent with their own, internal repertoires. Thus, without getting inside anywhere, we can know enough to realize there is agreement.

But this 'less' --- in the sense that the *overlap* of two, individual repertoires about some range of

mental processing is smaller than each repertoire has on its own --- is also 'more': because there comes into existence a new entity (a P-individual, to use Pask's terminology again) that did not exist before. In exchange for our mutual efforts, we unite. We lose our previous distinction, at least so far as an 'objective observer' can see. If there were a 'distinction meter', an instrument to measure whether there are any discernable boundaries inside of a mental repertoire that would indicate the vertical cleft between an A and a B as it is passed over each of us in the conversation, and (wonder of wonders) no boundaries can be detected. Because, cognitively speaking, we hold the same beliefs (the overlap) and so are one, closed system.

Of course this is true for a limited domain of interaction and any, even trivial expansion of this domain produces distinction again. In this way we could model the particular dynamic of human conversation when we are maddened by speaking with someone who insists on having 'the last word' --- insists on being different, in the end, when we have been trying to 'be agreeable' --- which is in itself not always so agreeable.

This architecture of languaging also affords the means of modeling so many such variations:

1. When you are being cheated (their L<sup>2</sup> is implied to be, but is not, the same as yours).
2. When we are in close sympathy with someone (a single, simple transaction evokes so many higher levels, and so quickly).
3. Why gifts are wrapped (to maximize their impact or 'power', in the literal sense of the rate at which energy is transferred, where energy is analogous to the shared understanding within a relationship).

So many images can be drawn; I believe that any conversation, any interaction can be modeled within this architecture, and hence its unique expressive power.

Consider, if you would, what happens when A and B are actually in the same physical body; all that I have said applies.

## 21. Machine Conversants

Pangaro: The architecture of conversation can be used to conceptualize human-machine interaction. For example, A is the human and B is the machine. L<sup>0</sup> transactions might concern numerical calculations, graphical aids, and so forth. L<sup>1</sup> transactions might concern inductive processes, organizing and learning routines, personal histories. To create this, as was Gordon's proposal in 1975, would be to create an 'Architecture Machine' <Pask, Gordon: "Aspects of Machine Intelligence", in Negroponte, Nicholas (Ed.): *Soft Architecture Machines*, MIT Press, Cambridge, Massachusetts, 1975> --- though I am punning on my use of 'architecture' and his, because he was writing at the request of Nicholas Negroponte, at that time founder and head of the 'Architecture Machine Group.' Nicholas' meaning of architecture was 'the built environment' writ large, namely, the environment as physically constructed. I enjoy the play, here, because Gordon's 'architecture' so beautifully characterizes our environment as mentally constructivized [sic].

The repertoire of procedures available in B would be various interacting (through-looping) design aids, conversational partners. Still however the machine becomes a means of designing with oneself because A's processes are also mirrored by B, not enhanced in the way that another distinct, creative individual would perhaps do so.

To use the machine as a conversational tool across time and space is not so difficult; it requires the addition of a storing medium. A similar use is when the machine is an interlocutor between, say, teacher and learner {*showing Figure 34*}.

Figure 34.



Here there are two stages that occur in sequence: first the designated teacher interacts with a design aid or training aid (such as the one just described) to create a knowledge representation ( $L^1$  descriptions of relations) in a domain to be taught, say, how to be an insurance agent. Included here are descriptions of the elements, goals and relations of topics in the domain: the entities involved. In addition the system requires the input of  $L^0$  expressions, procedures for bringing about the relations of  $L^1$ , namely, how to perform the actions of an insurance agent which, when properly done, create the relationship between agent, agency, insured, insurance company, liability, risk, and so forth. These  $L^0$  aspects include tactical operations interpretable in various different contexts.

Once these representations are stored (and of course for this we would use our coherence structures and analogies as described earlier) the learner, at another time and place, then interacts with this representation in  $L^1$  and  $L^0$ . The trick is to substitute two separated conversations, each with a machine as mediator, for the direct, human-with-human conversation of face-to-face teacher and learner. What must be ensured in that mediation, is that understanding of the subject matter is conveyed (it should also be facilitated, efficient, even thrilling). How could this understanding be measured? Let us (shall we?) return to a previous argument, now with a more formal interpretation for the sake of applying it to our mechanical friend, the computer.

The architecture of conversation presented above, with its horizontal clefts, holds that understanding is captured in a closure that is present across  $L^1$  and  $L^0$  (remember always that 0 and 1 are arbitrary), such that the  $L^1$  procedures (goals) control  $L^0$  procedures (methods or actions) that return results to  $L^1$  that achieve the goals. Hence, in less formal terms, the participant can both describe a desired result and also how to achieve it; in addition the execution of the 'how' descriptions will bring about the result.

Hence to test understanding the requirements are quite simple: require both  $L^1$  and  $L^0$  utterances which, when coupled, form a closure, i.e., they 'make sense' together. As I claimed before, a human does this quite naturally, the computational engine that a living systems is, seems designed (destined?) to do so. For a machine-mediated testing procedure, various methods can be used to (1) show evidence of the relations that are an  $L^1$  description, and (2) carry out  $L^0$  descriptions, that is, perform an act that achieves the desired result. There is great flexibility to achieving these in modern computing environments, with simulations, graphical interfaces, even the crude 'natural language' facilities coming to the aid of the mechanical teacher/tester.

It is in this way that THOUGHTSTICKER, used as a training aid, can ensure that its 'though-looping' with the learner has achieved success, alias, the acquisition of appropriate closures of concepts by the learner.

## 22. The Dance of Agreement

Pangaro: Chicho says:

'... in terms of description, language is not in the brain or in the nervous system, but rather in the domain of mutual coherences between organisms. When the observer observes that this takes place, and that the distinctions realized here can be recursive, can be distinctions on distinctions in the domain, then we have language.' <Maturana, Humberto, "Everything is Said by an Observer", reprinted in *GAIA: A way of knowing*, Inner Tradition s/Lindesfarne Press, William Irwin Thompson,(Ed.), 1987>

It is not just training or computer mediation that can be usefully modeled by the architecture of conversation. Every attempt that I have made to use it as a means to understand the relationship of any two distinct individuals (whether persons or organizations or perspectives in one head) has yielded insight into the relationship. It can also make tangible those ideas that have intuitive appeal and yet would seem impossible to measure or characterize in any way, let alone have a structure that preserves its subjective qualities, its status for the observer as well as the participants, etc.

Take 'sympatico.' I will not try to define this term applied to human relationships, because the very definition must evoke what is shared but difficult to express. Rather I offer a description in terms of our architecture.

When a transaction occurs from me to you at some level, say  $L_i$ , there is an implicit level of goal above that; like the example where I want to avoid dehydration, avoid collapse, avoid death.... {Pangaro again places Figure 31 on the overhead projector} There are always higher levels, to the point of nausea (which, I think, is what Sartre's book was about). Similarly when I make a statement, give it, give a request, there are implicit 'reasons' for it, to higher and higher levels. Sometimes the ones nearby need to be explained, otherwise {in the voice of a discordant lover}, 'you don't understand me'; the very highest ones are implicit in our biological needs (as Chicho is increasingly talking about). In between are the cultural similarities that do not need explaining: offering a drink to visitors, not imposing on friends. Also in between are common knowledge, interests, and experience that correspond to similar repertoires of procedures on each side of the vertical cleft. And now you see where I am going: sympatico is the feeling that goes with an exchange at  $L_i$ , where many, many levels above 'i' do not need to be expressed across the divide --- they are 'understood', or 'given' (what a lovely metaphor *that is!*). This quality of sharing without defining every detail is a sweetness that is in marked contrast to the frustration of needing to explain oneself, and the usual separation that one feels, trapped in the closure of one's own world view. There is a magic in what is felt but unstated; known but not described. It is the feeling of being 'in sync.' It is perhaps why 'relationships' are so fundamental to living --- they are what living is. {Pause}

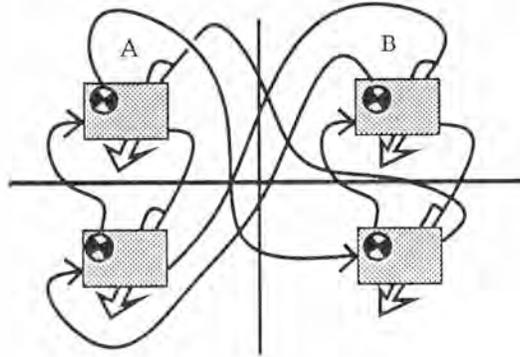
To complete the sweep that the architecture can express, one last moment.

It is of course the case that we could never transmit all possible, higher L levels to any starting transaction. Hence we are always implicitly treating each other as 'its' relative to our goals; in a

sense we cheat the other of the dignity to be treated at the same level we treat ourselves. (Consider applications in psychotherapy, where we treat *ourselves* as base.) Much of the time this is fine, because our biological and cultural commonalities make it symmetric, shared, and neither of us is (or none of us, in a larger context are) treated differently in the end. (This too is part of the shared space of living together.)

We can show this {Figure 35} as a criss-crossing of levels and boundaries, in a dance that seems to be 'across each other.'

Figure 35.



I wish to move gracefully in concert with you; this is my goal {pointing at the upper level in A}; this causes me to execute a method, below {running down along the vertical, control lines to the lower level in A}; I choose to sweep you across the dance floor. My execution of this method treats your goal like an 'it' {tracing from lower left to upper right} --- because you do not have the opportunity to respond or acquiesce to me. However, if your goal is in concert with mine, you {tracing from upper level in B to lower level in B} cause a method of your own to be executed, different than mine, which is perhaps responsive, or perhaps has an initiative of its own. This in turn treats my goal as an environment in which it can have its way {tracing from lower right to upper left}. Of course the points about feedback of results, and completion of closures, still apply. Except here each of us are using the other as

1. parts of ourselves, and
2. as our environment.

{Pause. He traces through the loops again in a horizontal, figure-8 pattern.}

Now let us break open this closed loop of control and describe what we see. I try to control you by treating you as my environment; I treat you like an 'it.' However, you consider that my intention, my goal, is consistent with your goals, and so you react in kind: you treat me like an 'it' in return. This in turn is consistent with my goals, and the result is stupendous:

1. There is mutual acceptance of what can never be known, that which is internal to the other. We agree to leave that out, and hence to lose our distinction.
2. We may assert our independence by adding new elements; however, there always remain 'higher' goals that maintain the consistency of our interaction.
3. We have an 'interaction' that leads to 'cooperation', maintained until some breakdown

occurs (failure, misinterpretation, loss of trust).

4. By this cooperation, our cognitive selves interpenetrate each other to the point where the boundary distinction collapses: we have created a new individual that transcends our own limitations.

If I have been effective with you here today, you will recognize (form your own closure) and realize that this 'Dance of Agreement' is a formal description of our daily experience. Gordon has spoken of it as capturing the notion of 'amity' and love. It is too what I believe Chicho means when he says languaging, as the consensual coordination of consensual coordination of actions, is a means of living together.

{Pause.}

Everything can never be made explicit; if you know all that is inside me, then you contain me and I am not different, cognitively, from you. If I also know all of you then there is no difference between us, and nothing new can be said. This is Gordon's distinction between conversation and communication. <Pask, Gordon: The Limits of Togetherness", in *Proceedings IFPS 80*, Tokyo and Melbourne, International Federation of Information Processing, 1980> The distinction neatly contains 'communication theory' and its obsession with the integrity of a channel that can carry only that which is pre-arranged to be a fixed alphabet. <Shannon, Claude E., and Weaver, Warren: *The Mathematical Basis of Information*, University of Illinois, Urbana, Illinois, 1964> There must be enough in common for an L transaction to make sense (other L levels must already be shared); else nothing ('no thing') can be said. In the glorious range where something is new to be shared, conversation and evolution can take place.

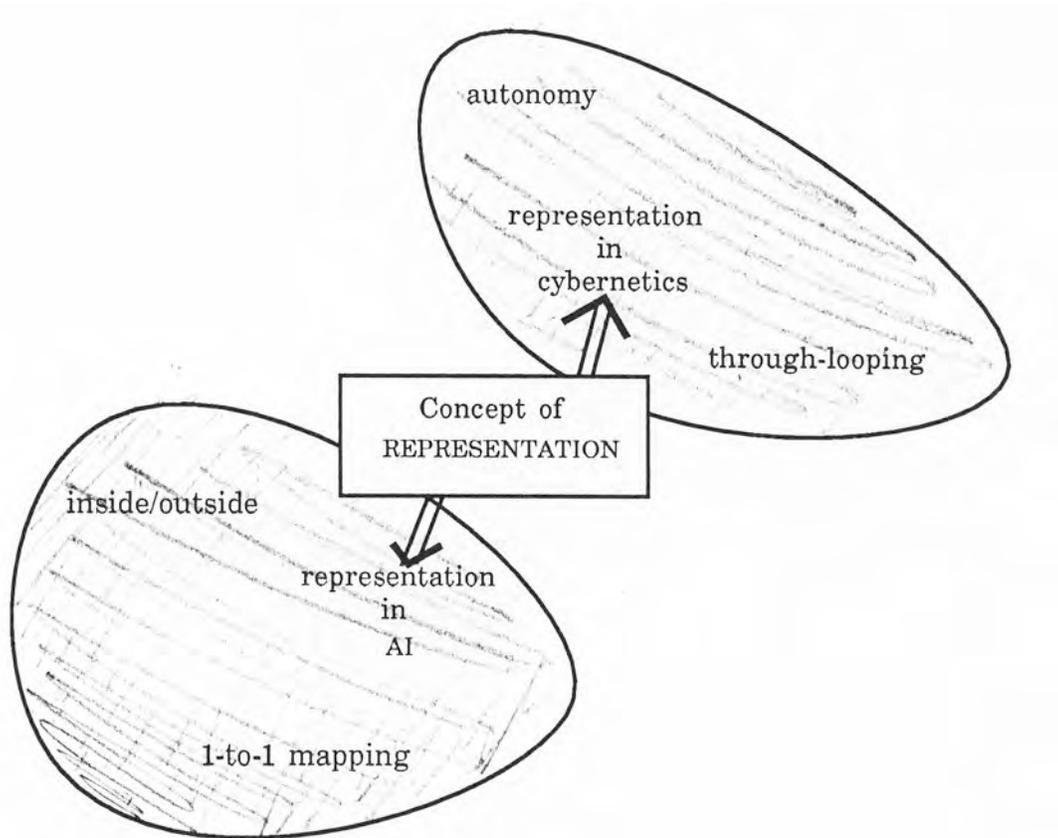
I claim again that the architectural model of Conversation Theory holds descriptive power for all interactions. The more there is in common (biology, culture, and what is normally called language) the more that the two (or more) individuals can presume what the other intends or needs or wants. I internally compute your side of the conversation/interaction; you compute mine. We are 'in sync' to that extent. Not all is already in sync; this is what is negotiated in the Dance of Agreement.

As these loops persist, and possibly increase in extent in what they encompass, there comes to exist a closure distributed across the distinction between us. This closure, where we have hierarchical goals and are acting to achieve them across the horizontal clefts, also crosses the vertical distinction between us. And here is what we call a miracle: in this domain of synchrony between two P-individuals, a collapse occurs and we lose our distinction; we become 'one.' In looping through each other, we no longer have a mental inside or outside: we are distributed in the conversation across a fluid distinction between us that is no longer a barrier. When inside and outside are lost, we have unity, amity, love.

## 23. The Technology of Intelligence: Summary and Comparison to present-day Artificial Intelligence

Pangaro: Now we can quickly come to some short climaxes {he places Figure 36 on the projector, but does not comment on it.}

Figure 36.



Pangaro:

- interaction is the start of everything
- our intelligence is the gathering or picking out of relations among experiences (*inter legere*)
- our world exists by mutual construction of observer and observed
- because all relates to the 'I', the world is subjective
- since we engage with the other in the world, our experience is consensual
- our experience is contextual
- our experience is purposeful
- ontogenesis (origin and development of the individual {*he looks at the audience to ensure they include the entire discussion of P-individuals, the architecture of languaging, and the collapse of distinction in the dance of agreement*}) is our concern in cybernetics

## 24. The Intelligence of Technology: Implications for corporate social change, networks and machine intelligence

Pangaro: Intelligence is not therefore in the brain, or in some knowledge representation placed in software. Instead it can be said to exist in the shared space brought about by participants who are languaging. There is a complementarity between the participants and the languaging, in that each brings about the other.

Varela says:

'... communication cannot be understood as instruction or information "transfer" from one organism to another. Whether the semiotic domain is extremely stereotyped (as in tissues interacting through hormones) or highly self-reflexive (as in human language), to put communicative information in a category comparable to energy or matter is misplaced concreteness, and confusing levels of descriptions. Animal communication is a network of interactions that has no basis except in its history of coupling and is relative to that history ... Everything said is said from a tradition. Every statement reflects a history of interactions from which we cannot escape, for it is what makes human language possible... a conversation is *direct* experience, the human experience *par excellence* — we live and breathe in dialogue and language. And from this direct experience we know that one cannot find a firm reference point for the content of a dialogue. There is no methodological escape from dealing with the elusiveness of understanding, and this makes it very evident that whatever is informative in a conversation is intrinsically codependent and interpretational. Whatever is said in order to fix and objectify the nature of a conversation's content is said from a perspective, from a tradition, and is always open to question, to revision, to disagreements. This is not failure or weakness, but the heart of the process.'  
<Varela: Op. Cit., pp. 268-269>

If however network transfers were to include explicit or implicit (but still required) coupled L<sup>1</sup> and L<sup>0</sup> expressions, thereby they would carry intention and purpose. The existence of such multi-level channels would minimize mis-understanding, for two reasons. First when the human being is required to explicate two or more levels of goals and methods, the thinking produced will be more careful and complete. Second, the system now has a representation of these multi levels that it can massage. The lack of common experience of the machine and the human would be less of a hazard since the coupled hierarchical goals would at least allow for some extrapolation on the part of the system to avoid contamination when asked for 'a glass of water.'

The machines too would not be receptacles but conduits for conversation with less lossage due to separations of time, distance, intentions. And a shared history would be supported by the software databases, which would maintain a sense of what has gone before and offer it consistently in the face of new actions, new situations. Not as a chastising elder but a willing partner, an aid to our mirroring of our lives and hopes and selves. And how if (when if?) the machine mirrors itself, creates distinctions and contributes new perspectives on the world?

## 25. Epilogue: Machine Narcissus

Pangaro: Now as I finish I can recapitulate in these terms: I have been concerned all through this presentation with how 'intelligence' might be constituted, and how it might be enhanced and if possible re-made via some mechanism. I have not explained intelligence; rather I have referred to its common notion, and outlined a different set of notions than one normally finds in the modern world, and especially the world of intelligence of the artificial.

Mythology tells of Narcissus, a tragic figure who fell in love with his own reflection, not realizing he was seeing an image of himself. So too in seeking to reproduce intelligence in modern AI we think we see universals of intelligence as independent of human life. Instead we see our own cultural view of what it means to think. Culture and its view of intelligence are complements: each delimits the other. Developments in AI and all other engineering sciences are both reflections of culture and influences upon it.

Recognizing oneself ('one as a self') then becomes central to intelligence. The mental places we inhabit provide distinctions we can make (our culture), and create a context for further distinctions that we invent (our evolution). To view ourselves on the outside, we model the cosmos. To view ourselves on the inside, we model intelligence. Everywhere between these extremes, our language and society attempt to unify experience, to smooth edges and create a seamless flow of description from inside to outside, macro to micro, within to among. After centuries of specialization and particularization, the movements of science inter-twine and converge: physics becomes computation, mathematics becomes reason, and conversation becomes epistemology. And if science allows biology to become cybernetics (remember synaptic gaps and the dance of agreement), intelligence can be captured in new forms.

Our story, then, begins and ends with a reflection of ourselves. Our insides project into the world, and the world reflects how we conceive. We project into ourselves, and our mind reflects back the universe. The nested reflections of science and culture, our world and ourselves, are the cycle of human endeavor that our common story is all about. At the center is what we name as intelligence. Our naming makes it ours. At some time, 'a machine intelligence' may also do naming, drawing distinctions of the world in its own terms, just as the old story says Man and Woman were commanded to do.

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