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Cybernetics in Society and Art

Abstract:

This paper argues that cybernetics is a description of **systems in conversation**: that is, it is about systems "talking" to each other, engaging in processes through which information is communicated or exchanged between each system or each element in a particular system, say a body or a society. It proposes that cybernetics describes the process, or mechanism, that lies at the basis of all conversation and interaction and that this factor makes it valuable for the analysis of not only electronic communication systems but also of societal organisation and intra-communication and for interaction within the visual/electronic arts.

The paper discusses the actual process of Cybernetics as a feedback driven mechanism for the self-regulation of a collection of logically linked objects (*i.e.*, a system). These may constitute a machine of some sort, a biological body, a society or an interactive artwork and its interlocutors. The paper then looks at a variety of examples of systems that operate through cybernetic principles and thus demonstrate various aspects of the cybernetic process. After a discussion of the basic principles using the primary example of a thermostat, the paper looks at Stafford Beer's *Cybersyn* project developed for the self-regulation of the Chilean economy. Following this it examines the conversational, *i.e.*, interactive, behaviour of a number of artworks, beginning with Gordon Pask's *Colloquy of Mobiles* developed for Cybernetic Serendipity in 1968. It then looks at some Australian and international examples of interactive art that show various levels of cybernetic behaviours. These include Stan Osotja-Kotkowski's interactive paintings of the early 1970s, Mari Velonaki's *Fish-Bird* robotics project circa 2006 and Stelarc's *Prosthetic Head* (2003-2009).

Keywords:
Cybernetics, self-regulating systems, Cybersyn, conversation, interactive art.

This article proposes that cybernetics, when all is said and done, is about the conversation: that is, about systems "talking" to each other, which itself is a process of communicating or exchanging information between each system. A crucial point is that this information has to be recognisable so as to change something within the "receiver", while the response or the "feedback" the receiver provides also has to be recognisable to the sender so as to change something in the original "sender", thus modulating/moderating their response. Therefore cybernetics is about conversation through both recognition, and change and adaptability within some system.

I use the term conversation because it is readily familiar. It is something that most of us *engage* in on a day-to-day basis, communicating with our partners, our colleagues, people we meet at parties or conferences, when we go to the shops, or a wide range of other situations, and these can include communicating with other species of living creatures as well as various species of mechanical objects.

In a more general sense, conversation takes place between all kinds of systems and especially those we think of as being living "entities" (i.e., having some quality of being a living thing (or showing signs of life)). It is this notion of 'living thing' that opens up the spectrum of things that will behave in cybernetic ways: e.g., human or animal bodies that undergo metabolic processes, and possess the capacity to fuel and supply those processes; ecological systems in which predator-prey processes occur or in which the shedding or excretion of waste products feeds some other class of entity within the overall proximal system.

Social systems, too, are usually cybernetic (although one might be justified in wondering about that these days). That is, they involve the operation of feedback structures that allow exchanges of various materials and information or the adaptations necessary to accommodate changes in the proximal environment.

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Page numbering begins at 1 at the start of the paper.

Cybernetics also operates in systems we usually think of as being mechanical. In fact when Norbert Wiener adopted the term he was thinking specifically about mechanical systems, although he had also already been introduced to notions of feedback control in neurological systems in his work with the Mexican neurologist Arturo Rosenblueth, particularly in the reduction of tremor (or "hunting") through proprioception in the limbs.[1]

Cybernetics, as a theory described by its mathematics, was developed by Wiener[2] out of the wartime need to dynamically point anti-aircraft guns so they would be capable of hitting an enemy aircraft while it was traversing the sky, given that the shell would take time to get up to the aircraft. So, in effect, it was a predictive method that accounted for the time it took for the result to occur, and it greatly increased the chances of the result occurring. It was developed by creating a mathematics in which the result, the output, could be fed back into the ballistic maths in real-time as one of the inputs so the artillery system could make the necessary accommodations.

But cybernetics has a much deeper past than these dark arts. Ultimately it drives evolution (though the loop may be generations long) and in a more palpable way it drives human evolution, particular in its social forms through one utterly important process: that of conversation, which, itself, will have come about through signalling processes; inevitably the signal that there is a predator nearby, or that this is where the honey is. Wiener also recognised that it was applicable in many areas of machine control, and that it was analogous to the behaviour of animals and people in many ways, for example in the development and coherence of societies. A particularly interesting example of the use of cybernetics in politico-economic systems was the Chilean Cybersyn project of 1971-73, which I shall come to shortly.

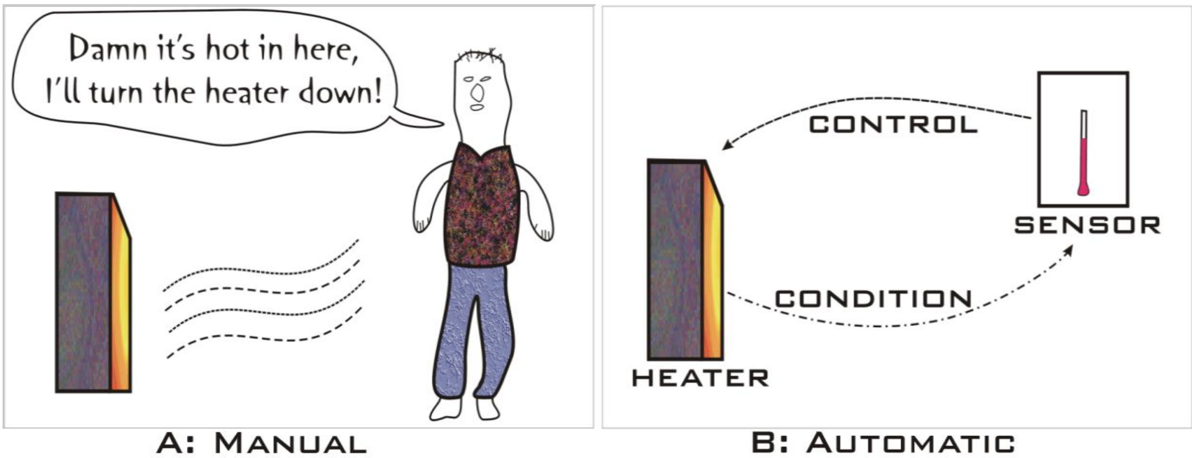

Fig. 1: The classic feedback control example of the thermostat. The sensor, human (A) or thermostat (B), senses the current condition and sends a control signal to the heater to modify its behaviour. [Graphic: Stephen Jones]

So, more formally, cybernetics is a theory of responsive (or adaptive) systems, in which reciprocal action-response (feedforward–feedback) cycles form the basic activity of communication. To illustrate, Wiener saw that in many circumstances the simple sending of a message to some device, say a heating system, was not going to be very useful unless there was some way of modifying that message so as to adapt to the changes that its implementation wrought. Continually telling the heater to increase the heat will only make the room unbearably hot, unless its occupant changes the message to say that we are warm enough now. To achieve some kind of automatic control over the heating system it must be equipped with sensors that provide appropriate information so that the feedback to the heater will be more or less useful in modulating the flow of what is, in fact, communication.

On a rather higher level, there is a biological/neurological need for feedback. It is necessary for the development of consciousness within each individual. At birth the infant is effectively mentally unformed, although some formative processes may have taken place while it is a foetus. But, shortly after birth, the first things that occur are that the nerves and the brain have to be educated through experience (i.e., their activity) that they are here for particular tasks, be those vision (in the short term) or speech (in the longer term). For example, the impact of

1 Rosenblueth, A; Wiener, N and Bigelow, J. (1943) "Behaviour, Purpose and Teleology" *Philosophy of Science*, vol.10, pp.18-24.

2 Norbert Wiener, *Cybernetics. Or Control and Communications in the Animal and the Machine*. New York, Wiley, (1948).

bumping into something, one's own body or one's mother, means that the affected nerves increase their association with movement or touch and the brain incorporates this in its logging of how to use the panoply of nerves that arrive at it to do the things that become necessary to do. Thus also, the brain, if it isn't appropriately stimulated, ignores the possibility that a lost stimulus might have generated (to be obvious, a deaf child will not learn language).

For Wiener, cybernetic processes fit into a larger category of *communications* systems. Communication is about the sending of *messages* between entities in which the message is a pattern of changes or differences (i.e., information) transmitted between the entities at either end of the channel. Supposing that the entity receiving the transmission is able to decode the message, then a communication has occurred, and in a certain sense a measure of *control* has been communicated between the entities.[3] This communication then becomes part of a *cybernetic* process when the receiver of the message responds, sending a message back to the original sender (which may be as simple as raising the temperature in the room), closing a loop of information between the two entities. Consider a conversation – I speak to you and you consider what I have said and produce a response back to me which I then consider. Supposing that I understand your response and respond in turn to you, we are producing a circular process that has a recognisable existence as a "conversation". This conversation will probably continue until one or the other of us fails to respond (a response in itself), or responds by stopping the process, and the conversation then ends [Fig.2].

The kind of information passed back to the source by the receiver, as some proportion of the output behaviour of the source, is called feedback and it becomes available to modulate the behaviour of the source in ways that are permitted by the construction of that source. When that proportion of information fed back is a function of some sort of *comparison* (*e.g.*, the success of the machine in reaching some goal) and inhibits the system, perhaps through being subtracted from the input, then the machine or the system is said to reach a basic level of *control*. Thus, as Wiener states, "control of a machine on the basis of its actual performance rather than its expected performance is known as feedback".[4] The process mentioned here is negative feedback and largely has a stabilising impact on the system of coupled components in which it is operating. Positive feedback on the other hand, in which the information fed back excites the system, can cause it to oscillate and go wildly out of control [Fig.3].

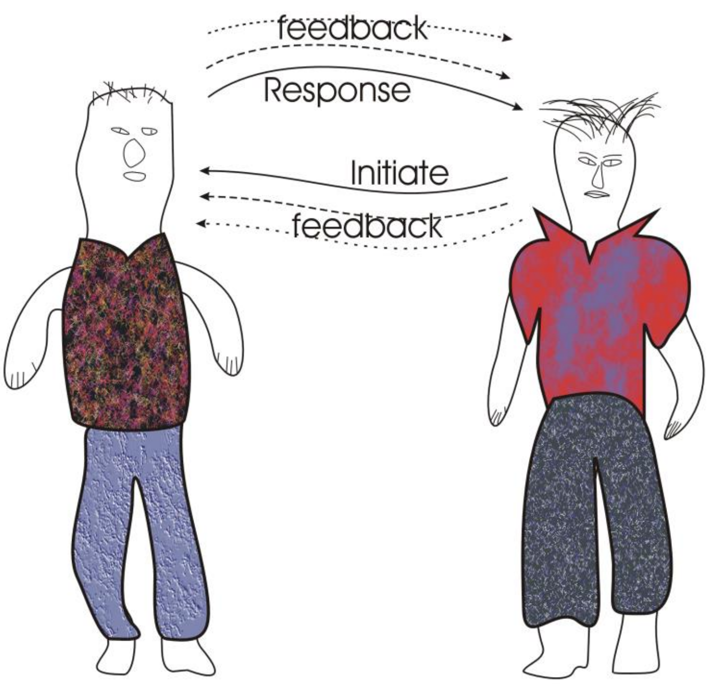

Fig. 2: A conversation is a two way interaction in which, after the opening gambit, each response is a feedback from the previous. [Graphic: Stephen Jones]

3 Wiener, Norbert (1950) *The* Human *Use of Human Beings - Cybernetics and Society*, Eyre and Spottiswoode, London, p.8.

4 Ibid, p.12.

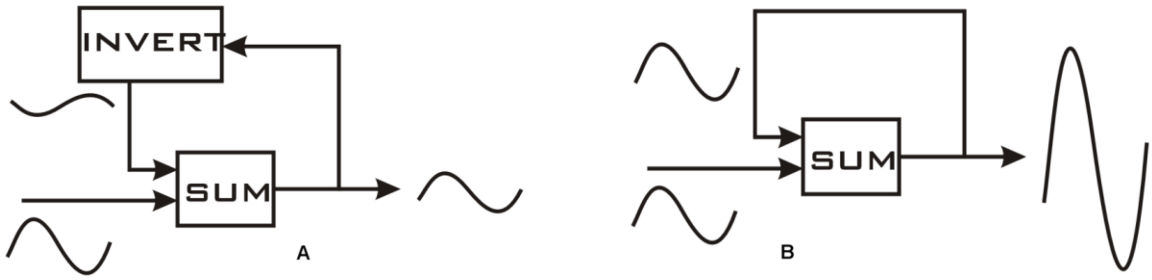

Fig. 3: Feedback can be either positive or negative (or anything in between). A: shows the inhibitory function of negative feedback. B: shows the tendency to oscillate caused by positive feedback. [Graphic: Stephen Jones]

Now, cybernetics does not simply operate on the small scale. As mentioned above, it is at the basis of large scale systems, such as ecologies or socio-political systems. I want now to venture into a description of a famous use of cybernetics in an economic system.

Stafford Beer and Fernando Flores – the Chilean industry coordination system – CYBERSYN (Cybernetic Synergy)

As the English cybernetician, Stafford Beer asked in *Platform for Change,* his post-1973 discussion of the potential of cybernetics in social, political, governmental and economic contexts: "What is cybernetics, that government should need it?". His reply is that it is "the science of effective organization"[5] that operates in all complex systems be they biological, neurophysiological, social or economic. He then argues that cybernetics is the tool that allows us to see that there are fundamental rules which, if not observed, lead to the breakdown of the system, to instability, to a failure to adapt and evolve.

The study of the cybernetics of a complex system, for example a political system, can show the way to making the system viable. A viable system has several important characteristics. Firstly it is **homeostatic**, in that it has a tendency to run towards a dynamic equilibrium condition, static equilibrium being the equivalent of death. In a dynamic equilibrium "the many parts of the complex system absorb each other's capacity to disrupt the whole."[6] It is in this point that, for example, biological diversity has its value. The more entities and species that are functioning within the system, the more opportunities for each member of the system to "absorb each other's capacity to disrupt the whole."

5 Stafford Beer, *Platform for Change*, London, New York: John Wiley and Sons, 1975, p.425.
6 Ibid, p.426.

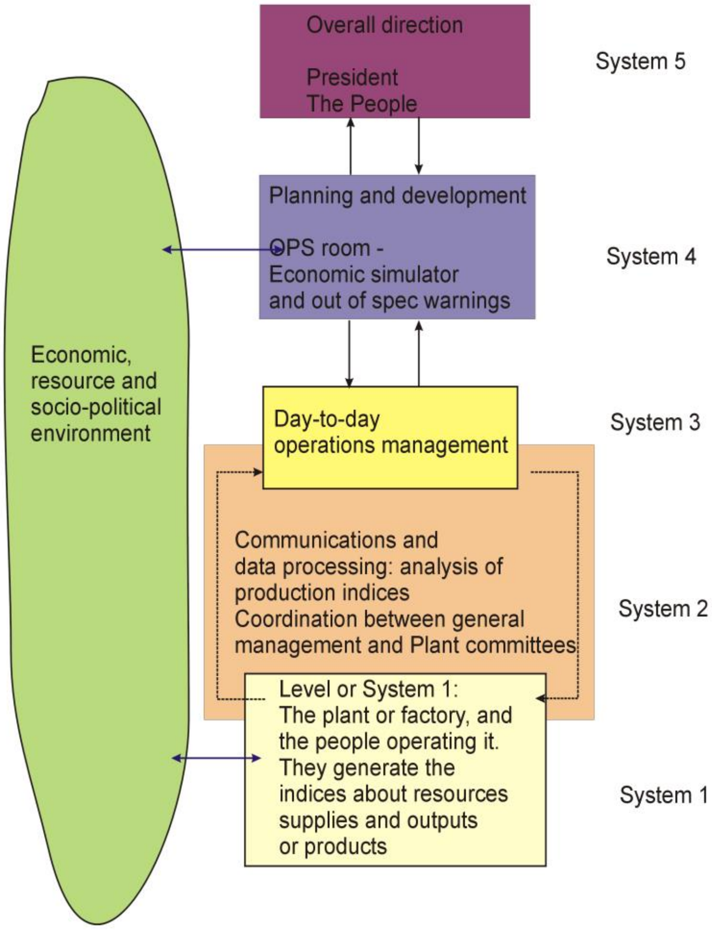

Fig. 4: The layers of viable systems that made up the Cybersyn project [graphic: Stephen Jones]

Secondly, it must be **adaptive**, in that a system should change in response to some environmental change. However a system in which the stable region is moved beyond the physiological capacity of its collective – for example if the surrounding climate becomes hotter and drier so that there is less water available in the system – it will then lose its adaptability and become disrupted largely through a loss of coherence.

These two conditions, and the fact that there should be constant real-time interaction between systems of the overall aggregate, contribute to its **viability,** which become the criterion against which the success/value of the system as organised was judged.

For Beer (who was a very successful operations research scientist and management consultant) the opportunity to produce an economically and politically *adaptive* and potentially real-time control system arose in Chile in 1971 when he was asked by Fernando Flores, the director of the Allende government's program of nationalisation of Chilean industry, to assist in producing a system to monitor and regulate its effects. Allende's program of nationalisation had led to a situation that was very difficult to control as it became more and more difficult to monitor. The problem became a matter of effective management and led to serious instability in the economy, and so Flores requested Beer's “advice on applying cybernetic principles to the management of the nationalised sector”[7] of Chile's economy.

Beer proposed “that a system based on a firm understanding of cybernetic principles could accomplish technical

7 Eden Medina, “Designing Freedom, Regulating a Nation: Socialist Cybernetics n Allende's Chile,” *Journal of Latin American Studies*, issue 38, 2006, 571-606.

feats deemed impossible in the developed world, even with Chile's limited technological resources" arguing that the "system should behave in a 'decentralising, worker-participative, and anti-bureaucratic manner'."[8]

The proposed system would "network every firm in the expanding nationalised sector of the economy to a central computer in Santiago, enabling the government to grasp the status of production quickly and respond to economic "crises in real time."[9] Named Cybersyn, it was a plan for a new technological system – developed (in 1971) by Beer and a small Chilean team – which would be capable of regulating Chile's economic transition in a manner consistent with the socialist principles of Allende's presidency.[10]

Cybersyn was based on Beer's notion of the viable system model (VSM), in which the system would be capable (through its variety of possible states) of adapting to ongoing changes in critical variables including inputs, resources and demands, thus maintaining its homeostasis within a workable range. The system would use feedback throughout the sub-systems of the VSM to link the people to their government. In the VSM the strata of systems into which the economy was divided each fed information up to the stratum above and downwards to the stratum below. The information going upwards consisted in data regarding available resources, the productivity of the factory and the social health of the workers. The data fed back down the strata consisted in how to maximise with the productivity of particular outputs, how to deal with crises, and the distribution of resources and products or output.

As Medina notes: "Beer constructed a five-tier model for viable systems, which he based on the human neurosystem. In spite of the model's biological origins, Beer maintained that the abstract structure could be applied in numerous contexts, including the firm, the economic enterprise, the body and the state."[11]

The VSM that Beer constructed for the Chilean economy was an hierarchical structure of the strata operating at each level of the company/organisation. Each stratum was to be a self-sufficient system which would only transmit problems up the hierarchy if necessary; if it couldn't deal with them itself. The lower levels, (levels 1, 2 and 3) governed daily operations, while levels 4 and 5 governed the direction and future development of the enterprise.

Level 1 handled supply of materials and the distribution of products, which also generated production indices, *e.g.*, how much was used and how much was produced.

Level 2 communicated the production indices to the various sectors, plant and factory, of
Level 1, and up the hierarchy to the director of operations at

Level 3, which looked after day-to-day management matters. These three levels were responsible for the overall functioning of the plant and handled the details that would otherwise have overwhelmed the management on the upper Levels 4 and 5. However major production problems that could not be resolved by the lower three levels were referred upward to Level 4 management, which was concerned with planning and enterprise development.

Level 4 was also the level at which the autonomy of the lower levels could be rescinded and a more centralised management could intervene. It was the stratum at which the senior management team met to consider the real-time flow of indices, and to whom the results of simulation of the production trends as compared to historical data were reported. It was the place in which a synopsis of the whole economic process could be seen and considered. If a parameter fell outside the expected range it would be flagged and a warning emitted to the head of the operations management team (on Level 3) at the particular factory concerned. The committee that considered these data at Level 4 worked in what was known as the Ops Room, a rather Space Age environment in which all the telex data and simulation outputs were displayed on screens.

Level 5 represented the CEO of the enterprise who "determined the overall direction of the enterprise."[12] Generally this was the president, Dr. Allende, although he always intended that it be the people themselves.[13]

It is the recursion, the ongoing conversation, within and between levels of the model that make it cybernetic.

8 Ibid, p.572.
9 Ibid.
10 Ibid.
11 Medina, op cit, p.583.
12 Medina, op cit, p.585.
13 Beer, op cit, p.447.

Each layer is capable of receiving data from its internal operation, of communicating that data to a higher level in the system, and each layer is capable of understanding the data fed back down to lower levels in response. The system is constantly adapting, more or less in real-time, to the changes and demands of the environment which, while being resources and supplies, also consisted of the people themselves.

Cybersyn was always designed “to provide an instrumental embodiment of Chile’s socialist politics,”[14] which involved worker participation in government and in the management of industry. There were also thoughts about devolving it to each factory by building a simplified ops room that could enhance local workers’ understanding of the factory's operations, assist their decision making and support the collectivisation of the factory so that each worker was less inclined to compete individualistically with others in the factory but would work towards an overall collective production output. Beer's interest overall was to expand Cybersyn type concepts to the political sphere. However these less technocratic aspects of his vision were not to be espoused by the Chilean engineers who were actually operating Cybersyn, nor the conservative opposition who argued that it would produce centralised or totalitarian (a la 1984) control (a projection, of course, of their own intentions), and hated the fact that it was intended to create an environment of workers' control.

But Cybersyn was to be tested and it succeeded hugely with its first test. The story is told by Andy Beckett of the Guardian newspaper:

> “Across Chile, with secret support from the CIA, conservative small businessmen went on strike. Food and fuel supplies threatened to run out. Then the government realised that Cybersyn offered a way of outflanking the strikers. The telexes could be used to obtain intelligence about where scarcities were worst, and where people were still working who could alleviate them. The control rooms in Santiago were staffed day and night. People slept in them - even government ministers. "The rooms came alive in the most extraordinary way," says Espejo. "We felt that we were in the centre of the universe." The strike failed to bring down Allende.”[15]

However it never even had a chance on the next attack. On September 11, 1973, (a notable date) the Chilean opposition, with the backing and encouragement of the U.S. CIA, launched a military coup against Allende's government. Allende was assassinated and the Presidential palace put to the torch. The Military tried to understand Cybersyn but couldn't and dismantled it. The rest is sad history and the hypocritical support of very nasty political leaders for the sake of the wealthy owners of various supposedly democratic governments.

But in this paper I am talking about **Cybernetics in art, something which is particularly apposite to Interactive art.**

In 1967 the notions of cybernetics were taken up by Roy Ascott in the UK. This step, along with the systems art movement and Jack Burnham's “system's aesthetic”, established the recognition of and, for a short while, direct push into a cybernetic art. These early practices mostly consisted of interactive art. In a 1966-67 paper in *Cybernetica*, Ascott spoke of “art that behaves”, art that is intended “to draw the spectator into active participation in the act of creation” and that to accomplish this “a feedback loop is established so that the evolution of the artwork/experience is governed by the intimate involvement of the spectator.”[16] It is this notion that lies at the basis of interactive art: the artist wants to engage the viewer in a dialogue and this interplay is necessary for the completeness of the work.

Not long after this, in his 1968 book *Beyond Modern Sculpture*,[17] Burnham developed his systems aesthetic (derived in part from the cybernetics of Wiener but also from von Bertalanffy's *General Systems Theory*). This aesthetic theory was a means for understanding developments in art arising from Kinetic art and what was then becoming conceptual art and was otherwise leading into systems art, some of which involved various aspects of computing (given a wide ranging definition of that concept). These are the kinds of developments that Donald

14 Medina, *op cit*, p.596.

15 Andy Beckett, “Santiago dreaming,” *The Guardian*, Monday 8 September 2003 [http://www.guardian.co.uk/technology/2003/sep/08/sciencenews.chile]

16 Ascott, Roy (1967) “Behaviourist Art and the Cybernetic Vision,” *Cybernetica: Review of the International Association for Cybernetics*, vol.9, no.4, 1966; vol.10, no.1, 1967, p.29.

17 Jack Burnham, *Beyond Modern Sculpture. The Effects of Science and Technology on the Sculpture of this Century*. Allen Lane: The Penguin Press, London, (1968).

Brook discussed in his lecture "Flight from the Object".[18] However systems art, while potentially being proactive, is not necessarily fully cybernetic.

Also in 1968, the ICA in London presented *Cybernetic Serendipity*, curated by Jasia Reichardt.[19] This exhibition attempted to show examples of almost all versions of art that in some way or another involved the computer in its making. It included many works in which I would argue there was little actual cybernetic process, but one or two showed it off well. I will come to one of these, Gordon Pask's *Colloquy of Mobiles*, shortly.

So, what is cybernetic art? To my mind, it is any work that by some process is capable of recognising, understanding, and taking into account some aspect of any information that is reflected back to it from its output or behaviour. This is feedback, and it is necessarily constitutive of one form or another of **interactive art**.

The crucial point is that both the artwork and its spectator/interlocutor must possess the capacity to understand and act appropriately on the output of the other, the feedback. This would require a common vocabulary of some kind, *i.e.*, the content of the feedback has to be understandable by the entity to whom it is directed. And of course, depending on how far apart the species of entities (objects and audiences) are, it may require a considerable amount of learning to take place over the process/period of the interaction (even if these occur as a number of sessions).

However there is a caveat: **while interactive art may have many of the factors necessary to a cybernetic process, it is by no means necessarily cybernetic.** Entities engaging in interactive art must possess the ability to change their state to accommodate changes in their environment. This is a necessary first condition that has to be possessed by any entity that will undergo interaction. Interactive artworks occupy a wide range of levels between the potential fully conversational robot and the video replay that simply switches on when the spectator enters the gallery.

Interaction involves engagement with, usually, a single other entity (person or machine), and is one-to-one. The work is not complete without the interaction, but the focus will be on reciprocal relationships and their development over time. To interact is usually considered to involve engaging with devices of varying kinds, through the exercise of controls or sensors or other data gathering attachments that provide information as to changes in local conditions, and thus permit the spectator, as user, to participate in the process of the thing so that some kind of reciprocal relationship develops with it.

Interaction may simply be a process of controlling some machine, for example in the way that one drives a car (it will generally not talk back, or at least not yet). Or, for example in art, interaction would ideally involve engagement with, usually, a single other entity (person or machine), and the work is not complete without the interaction, but the focus will be on possible reciprocal relationships and their development over time. The key is that some sort of communication transpires; a reciprocal exchange of (generally 'meaningful') information that endures because of that meaningfulness and its reciprocation.

But for this to occur it must be able to sense its environment and affect internal changes that accommodate those sensed external changes. These processes are structurally fundamental to interaction, and they constitute the primary level of the process of communication.[20] They require the two orthogonally related conditions of 'autonomy' and 'agency'.

By any measure the peak class of interaction is conversation – an ongoing, inherently stable, multi-sided, adaptive process of information transfer, that consists in alternating, reciprocal production and transmission of information and response to that information, through consideration, recognition (of signs), understanding (of their meanings), development or extension of 'ideas' embodied in the messages and the production of further transmissions. That is, conversation must involve *understanding* which is a function of a mutually agreed, or learned, set of signs (language) that convey the meaning.

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18 Brook, 1970, *op cit*.

19 Jasia Reichardt, *Cybernetic Serendipity: the computer and the arts*, London: Studio International (1968). Catalogue of the exhibition held at the Institute of Contemporary Art, Nash House, The Mall, London, August 2 - October 20, 1968.

20 Stephen Jones, "Interaction Theory and the Artwork," in *Interaction: Systems, Practice and Theory*, ed. Ernest Edmonds and Ross Gibson, (Sydney: University of Technology Sydney, 16–19 November 2004): 283–303.

Conversation necessarily involves feedback; the closing of the loop through the response by the second party, which is in turn considered and responded to by the first. Thus a continuing circle of feedback undergoes temporal development as the conversation continues, and each party is, at least, able to utilise its existing repertoire of behaviours – ranging from language and gesture to the demonstration of objects and processes or the operation of machines. This circular feedback relation, though largely neglected in contemporary art over recent decades, provides a framework of immense value in understanding how interactive systems can work. It is the circular feedback system that renders the conversation something greater than what exists within each party, such that its coherence gives it a mutually embodied autopoietic presence.

More interestingly, in any intelligent entity (living or artificial) the learning of a set of signs to convey meaning will require the development of new behavioural repertoire through a process of adaptation.

Regarding conversation, and paraphrasing a member of the original group of British cyberneticians, Gordon Pask:[21]

1. Conversation between individuals occurs over time and alters the mental contents of each individual over that time.
2. Conversations have a start and a finish and unfold over time, although they may run in parallel, supposing more than two individuals are engaged.
3. The conversation is in the *intersection* of the minds of the individuals engaged. That is, it exists as a superstructure that is not contained exclusively in either mind but is necessarily a function of the activity of both. This is what I mean by saying that the conversation embodies an autopoietic structure.
4. There is a process of feedback that gives conversation its unified character.
5. There is a “transfer of tokens” (language, signs) between each individual within the conversation.
6. These 'tokens' must be mutually understandable. However, the interpretations of the conversation are nevertheless a function of each individual mind.

Examples of art that behaves and may interact with its audience.

Gordon Pask's *Colloquy of Mobiles.* This work from one of the British cyberneticians constituted what Pask thought of as an “aesthetically potent environment” that “encourages the hearer or viewer to explore it, to learn about it [and] to form a hierarchy of concepts that refer to it.”[22] It consisted in a group of mobiles that engaged in discourse with each other and in which the spectator could be engaged if he or she wished. Two types of mobiles are involved, each of which have a selection of programmes and drives that allow them to learn “how to deploy its programmes in order to achieve a goal.”[23] Members of each type may have cooperated with a member of the other type to achieve a goal, “for one possesses programmes that are not in the repertoire of the other and jointly [the two types together] can achieve more than both individuals in isolation.” The mobiles must communicate to achieve this cooperation which they do “in a simple language of [different coloured and time modulated] light flashes and [different tones and time modulations of] sounds”[24], and the spectator may also engage in this discourse if they wished.

Each mobile has several needs which it tries to satisfy, but to do so it must engage with a mobile of the other type. For example, type 1 mobiles possess a light which casts a beam outwards but cannot be focussed on itself, however to satisfy one of its needs that beam must strike it on some otherwise inaccessible part of its 'anatomy'. To do this the beam must be reflected back onto it by a mobile of the second type. So first, the originating mobile must seek out a mobile of the second type by sending out intermittent light signals and searching by rotating about its axes. If the search is successful type 2 mobile synchronises a sound signal with type 1's flashing light and, once it has detected the correlated sound signal, it stops its rotation and replies to the type 2 mobile with a short flash of its orange light. At this point the type 2 mobile reflects type 1's orange beam of light back onto type 1's receptor and its goal satisfaction is increased, and the type 1 mobile emits sound signals indicating it has

21 Gordon Pask, “Heinz von Foerster's Self Organization, the Progenitor of Conversation and Interaction Theories.” *Systems Research* vol.13, no.3, (1996): 351–364.

22 Gordon Pask, in Jasia Reichardt, *Cybernetic Serendipity: the computer and the arts*, London: Studio International (1968), p.34. This is the catalogue of the exhibition held at the Institute of Contemporary Art, Nash House, The Mall, London, August 2 - October 20, 1968.

23 Pask, *op cit*, p.35.

24 Pask, *op cit*, p.35 and Pask, “A comment, a case history and a plan,” in Jasia Reichardt, *Cybernetics Art and Ideas*, Greenwich, Connecticut: New York Graphic Society Ltd, (1971), p.89.

received the reinforcement of its satisfaction seeking and the 'conversation' is then able to continue.[25] To provide similar satisfaction of need for type 2 mobiles the type 2 mobile needs to receive the reinforcement in response to the type 2's correlated sound signal.

The mobiles of both types generate an intriguing and aesthetically potent environment. Pask notes that the mobiles produce quite complex patterns of light and sound which spectators may have some chance of interpreting, and suggests that if a spectator were given the means to produce signs in the mobiles' language it would be quite possible for them to communicate with the mobiles. If they did they could use similar patterns of signs to interact with the mobiles and they may well become engaged in a higher level conversational system with them. Pask goes on to note that he doesn't know what might happen then.[26]

Meanwhile in Australia
Stan Ostoja-Kotkowski's interactive sculptures and paintings.

The sculptures, such as the Laser Chromason, were largely synaesthetic devices that responded to contextual sound with light and colour, but didn't generate much primary (or originary) output. However a number of his interactive paintings driven by a Theremin did. These were paintings made either in baked enamel on steel or as fine sand blasted op-art patterns also on steel. The steel "canvas" meant that the painting itself could be utilised as an antenna for the theremin, and if you stepped up to the painting and waved your hands before it, it would growl and whistle and eventually scream the closer you got the picture. Thus the paintings were a system that could be played, both by an unskilled audience and by a skilled musician who might able to control the pitch of the "instrument".

Ostoja-Kotkowski was a serious maverick and while, particularly in the 1970s, he continued to produce works like the interactive (or Theremin) paintings, he had previously, around 1966, proposed such wild things as a control panel that could allow the artist to play the ensemble of video raster-manipulation devices built for him by Philips Industries in Adelaide and with which he made (c.1962-66) a remarkable series of photographs of twisted 3D raster images that were not far from the work of Herbert Franke. This may well have been the first description of a video image synthesiser.[27]

But even more interestingly he proposed later that the control system for a large scale presentation event could be directly controlled by the artist's mind if a device, based on the EEG, could be built that would draw enough detail from the EEG signals to apply to the controls of different sections of the production system. As he suggested

> "the translation of the activities of alphawaves into forms, colours, shapes and movements is technically possible. By the use of computers, a development of electronics used on my previous experiments with light, optics, polarchromatics and lasers would provide enough variety of basic material for the performers-composers-artists to draw on, and to make their conceptions audible and visible to the audience."[28]

However, this is an idea for which, even now, small breakthroughs are made, although the differentiation of control details is still a major problem. Should it become possible then we really will be able to enter into direct conversation with the machine.

Another of the early experimental artists working in Australia was the dancer **Philippa Cullen**. She was a thoroughly trained modern dancer who had her main active period between around 1969 and 1975 (in which year she died in India). She developed an interest in being able to dance to music that she and her company generated from the dancing. *i.e.*, the creation of a loop in which the dance made the sound and the sound then drove the movements.

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25 Gordon Pask, "A comment, a case history and a plan," in Jasia Reichardt, *Cybernetics Art and Ideas*, Greenwich, Connecticut: New York Graphic Society Ltd, (1971), p.89.

26 Ibid, p.91.

27 Stephen Jones, "Josef Stanislaw Ostoja-Kotkowski: Light becomes the Medium", *Meanjin*, vol.68, no.1, (Autumn 2009). Stephen Jones, *Synthetics: Aspects of Art & Technology in Australia, 1956-1975*, Cambridge, Mass.: MIT Press, (2011).

28 J.S. Ostoja-Kotkowski, "Investigation into the possibilities of the use of alpha waves in the creative arts", Washington, DC: The Conference Board of Associated Research Councils, Committee on International Exchange of Persons, (1973).

She saw a theremin being used in an interactive video and sound installation by Optronic Kinetics at the Tin Sheds at the University of Sydney and realised that the theremin they were using, which had a very long wire antenna, would work perfectly well on stage. She asked the electrical engineer, David Smith from Optronic Kinetics, to build her a similar device, with which she practised to work out what kind of movements would work with it. She then set up a group of nine dancers, three of whom would lead the movements and six of whom would act as a kind of 'Greek chorus' in background movement. The work was presented as *Electronic Aspects* (1970) in the Union Theatre at the University, but Cullen realised that the continuous sine wave tones were not very interesting. She was studying at the University and met a musician named Greg Schiemer and another electrical engineer named Phil Connor, and together they devised a new approach to the theremin in which its sine-wave output of varying frequencies could be used to great effect with the aid of a frequency-to-voltage converter and a peak detector which acted as control voltage sources for an EMS VCS3 audio synthesiser.

The result of all this work was *Homage to Theremin II* (1972) which she and her company (including Jackie Carroll and Deirdre Evans) performed at International House at the University of Sydney in April 1972. A collection of interesting antennae had been designed by Manuel Nobleza and with these and the reworked audio synthesiser they performed a dance work in which the dancers interacted directly with the thermins, having previously learned how to use them to make a very wide range of interesting sounds.

Cullen went to Europe after this and after about a year returned with a set of new ideas, among which was a proposal for a set of pressure sensitive floors. These were built for her by Arthur Spring and used in March 1975 in Canberra at the Computers and Electronics in the Arts program of Australia '75. She went overseas again after this and, being already quite ill, much to everybody's horror at the loss of such an inspiring person, she died in India in July 1975.[29]

In the same way that Cullen's dancers entered into a feedback driven conversation with the synthesiser, so does the musician also enter a cybernetic loop when playing an instrument. Even more interestingly, this becomes a social cybernetics when he or she is playing, and especially improvising, with a group of other musicians.

But it need not just be musicians. Any artist/performer who works live, such as someone playing a video synthesiser, is going to enter into a feedback loop with the system of instruments, presentation mode (screens or speakers, say), other musicians and audience. In that process the audience will often offer a particular form of feedback that will modulate performance. This would be obvious with a comedian for instance, but actors in the the theatre generally have this feedback available, as do people giving presentations and lectures.

Mari Velonaki – Fish-Bird[30]

To the audience Fish-Bird appear as a pair of wheel-chairs (thus rather disarming one's notions of the autonomous creature) quietly rolling about the gallery space, among a mess of short thermal-paper printouts all over the floor. Go quietly into their space and sooner or later (not that much later) one of them will tootle up to you like a shy animal coming to sniff you out. If you sit quietly it will hang around for a little while and then wander off, if you're active and noisy it'll get out of your way. Stay a little longer and observe their behaviour. They move towards each other or the audience – they know where the audience is and will seek them out – and one will print out a text. They also know each other's location, and they move towards each other as if seeking each other out, or break off into separate areas of the space. They also write their poems to each other.

Their behaviour may well be a mystery, however, given our culturally imbued tendency to slow down and watch the "robot" our stillness will attract it. Initially it may turn to face the spectator when they enter the gallery, while subsequent "changes of speed and direction are used to convey mood and intention."[31]

They engage in constant communication with each other about where they are, their mood, the poems they release and where the audience is. Also, they regularly attempt 'conversation' with the audience by coming up to you and perhaps dropping a printed poem at your feet. The printed poems are intended both for you and for each of them. While they appear to be only printouts, a complete version of each poem is also transmitted wirelessly

29 Stephen Jones, "Philippa Cullen: Dancing the Music", *Leonardo Music Journal*, vol.14, pp.64-73 (2004). Stephen Jones, *Synthetics: Aspects of Art & Technology in Australia, 1956-1975*, Cambridge, Mass.: MIT Press, (2011).

30 http://www.csr.acfr.usyd.edu.au/projects/Fish-Bird/index.htm

31 http://www.csr.acfr.usyd.edu.au/projects/Fish-Bird/Background.htm

to the other of the pair.

At the technical level the overall installation is monitored for audience presence and wheel-chair location by laser-scanners on the periphery of the space and video cameras in the ceiling. Their behaviours are constrained to seven behavioural sets that are governed by the resolution of a set of conditions – an index of mood determined by the day of the week, the time you spend with them, their internal condition, the current state of their relationship to each other (their interaction) and the behaviour of the spectator. The software system attempts to identify the behaviour of each participant in the installation space from their movement, and adjusts each robot's 'emotional' state on the basis of identified patterns.[32] These are encoded in a finite state machine and govern their interaction with each other and with you.

The conversation is carried through a central controller via Bluetooth using "the Active Sensor Networks architecture".[33] It is understood through a small pre-set lexicon, of which each term is meaningful to Fish and Bird. However the conversation with the audience is not so easily interpreted and while some level of consistency, due to more or less normal polite behaviour, is operational it is also up to each member of the audience to reach their own interpretations of, and to learn, the robots' behaviours. Between the robots, the content of the conversation loop is mediated through the processing of the laser and camera data by an installation controller system. This in turn stage-manages the wheel-chairs which seem to be interacting with each other and with the audience in a gently sentient manner. All this is not at all obvious to the audience, however they are included in the conversation loop (if they stick around long enough) and they also become partial content of the conversation between the robots.

If a truly autonomous cybernetic version were to be developed it might have to make its communications overt and clearly recognisable to the other, so each would have to carry their own proprioceptive, sensing and behavioural systems and ideally develop, over some growth period, sets of appropriate behaviours. It is these behaviours that become the signals, overtly sensible events, and each creature would need to be able to "see" that the other's behaviour is analogous to something it can do. That is, the signal triggers an internal, pre-established sequence. Communication here becomes a kind of dance.

Stelarc's Prosthetic Head[34]

The Prosthetic Head is a large video projection of a 3D model of Stelarc's head. It responds verbally to questions or comments typed into a keyboard on a plinth set in the gallery space in front of the projected avatar. The Head's responses are selected from a set of installed phrases based on the knowledge that Stelarc gives it. It also has a range of gestural responses: smiles, head movements, eye movements and gaze, and can seem to become quite involved in the conversation. It uses an embedded conversational agent software (a la *Eliza*) to generate its responses from its internal knowledge and your questions.

It appears to be generating feedback that is directly related to your enquiries, but since it selects from a pre-specified set of sentences, this is actually an illusion. This is because, as yet, it has no capacity to generate novel statements. The feedback is what you provide based on its selections and your interpretation not so much of what it said but of why it might have said it. It functions as a product of our projections – and this brings up an important question: to what extent do we all do that when we are relating to each other?

However the Prosthetic Head is structurally open enough to make a wonderful test bed for experimenting with most of the technical (*i.e.*, computer-based) ways of learning, recognising and generating speech. It is also potentially valuable as a vehicle for developing vision, especially in face and gesture recognition. The evidence so far is that all of these processes do not seem to be possible through top-down AI-programming but are more the kinds of things for which neural networks are useful. So if one was to develop new artworks from this approach it would be useful to include a great deal of the work coming out of neural nets and especially neural and self-constructing hardware systems.

Creating a Speaking Machine

I am prompted by these thoughts to ask how we could develop a machine that could speak spontaneously and respond generatively to verbal stimulus? First, it has to have an engine for generating sounds (like phonemes), then it has to have an engine for linking sequences of sounds into 'somethings' analogous to words, each se-

32 http://www.csr.acfr.usyd.edu.au/projects/Fish-Bird/Background.htm
33 http://www.csr.acfr.usyd.edu.au/projects/Fish-Bird/Realisation.htm
34 http://www.stelarc.va.com.au/prosthetichead/index.html

quence then being required to connect to some kind of state of knowledge of itself or its world, or more usefully to be the ‘mental’ representation of that state of knowledge. This is self-constructing hardware implemented in us through the plasticity of our neuro-physiology, our brains. This then confers a meaning on the sequence. But, more importantly, the sound generating engine has to be controlled by the listening engine so that the machine has a means of modulating its sound/phoneme generation so that the sounds its ‘teachers’ hear start to be recognisable and understandable. As the machine learns to babble in more and more coherent ways, its feedback reception and production reward it more and more so that the pleasure of communication, and especially of getting what it wants, motivates the process. One could think of the overall set of production and listening engines as a desiring machine, a la Deleuze and Guattari.

One final work that demonstrates a considerable level of conversational behaviour (even if its language is obscure) is **Ken Rinaldo’s *Autopoieses*[35]**

In the American artist Ken Rinaldo’s ***Autopoieses*** a robotic sculptural group “interact[s] with the public and modify their [own] behaviors based on both the presence of the participants in the exhibition and the communication between each separate [object].” The sculptures “talk with each other through a hardwired network and audible telephone tones, which are a musical language for the group.”[36]

It consists of 15 articulated robot sculptures made from grapevine and which give the distinct impression of being arms hanging from a grid in the roof of the gallery. It senses the presence of the spectator through infra-red sensors placed at the top of each arm, and when it knows that there is a spectator in the gallery it can respond appropriately by 'pointing' or swinging towards them. As it is moving, an infra-red sensor in the tip of the arm limits its approach to the spectator. A central controller assists the sensors to coordinate their behaviour so that a spectator can move through the “installation and have the arms interact both individually and as a group.”[37]

Each arm's movement and speed is delicate and accurate. The arms and the central controller communicate on a private network. The controller gains “a feel” for the overall environment from the strings of data generated by the arms and some knowledge of the number of spectators in the gallery. If the number of “sensor hits” is large then the arms' behaviour becomes less vigorous, but as the number drops “the arm's behaviors become more vigorous and large group behaviors are expressed.”[38] Group sculptural form and sound may also evolve through the generation of random numbers in the central controller's state machine. The sounds – telephone tones – constitute “a musical language that allows individual arms to communicate and give the viewer a sense of their emotional state.” Rinaldo notes that “the telephone tones are a consistent language of intercommunication and manifest a sense of overall robotic group consciousness, where what is said by one effects what is said by others. *Autopoiesis* continually evolves its own behaviors in response to the unique environment and viewer/participant inputs. This group consciousness of sculptural robots manifests a cybernetic ballet of experience, with the computer/machine and viewer/participant involved in a grand dance of one sensing and responding to the other.” [39]

35 see http://www.kenrinaldo.com/
36 http://www.kenrinaldo.com/
37 Ibid.
38 Ibid.
39 Ibid.