A Cultural Systems Approach to Collaboration in Art & Technology

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Abstract

In this paper I take a wider, cultural theory based, view than is usual in the literature of collaboration and its role in creativity. I will explore the nature of the collaborative interaction as a cybernetic process and draw on the systems theoretic approaches of Burnham's systems aesthetics, Wiener's cybernetics, Deleuze and Guattari's machinic phylum and Maturana and Varela's autopoiesis to build up a cultural framework of the interactive behaviours between individuals that constitute collaboration. I then canvass some actual historical collaborations as well as my own personal experience as both an artist working in Art & Technology and as a technologist working for many other artists. I will also look at some of the empirical work that has been done on collaboration and explore how it and the historical and personal experiences fit into the structure of interactive relations that the cultural systems approach has brought out.

Categories & Subject Descriptors: H.5.m [Information Interfaces and Presentation]: Miscellaneous - Collaboration.

General Terms: Human Factors.

Keywords: interaction; collaboration; feedback; autopoiesis; cybernetics; systems theory; cultural theory.

INTRODUCTION

It is usual that artists explore new regions of technology, and they may contribute substantially to its development (from, at least, Leonardo da Vinci onwards [6, 25]). This exploration requires that the artist have some means of gaining access to, and understanding of, the technology they become interested in bending to their purposes. But with artists trained in aesthetic matters and the cultural theory and history of their field, they are often ill equipped to work with complex technologies. It is this factor that may incline any artist wishing to work within the domain of contemporary Art & Technology and digital art towards collaboration as a necessary means for realising their intentions (desires). This collaboration will usually operate between two practitioners, the one who has the technical skills and the one who has the artistic intention and aesthetic skills. In rare cases it may be that the one person has acquired both, that is, the artist may have learned the necessary technological skills. This most often seems to apply in artforms which are more akin to traditional forms, eg, in photography or contemporary digital printmaking.

However, much Art & Technology production is going to involve a collaboration between an artist and one or more engineers either directly, in the design process, or indirectly, in the artists' use of already designed technologies that may or may not be entirely appropriate for the artists' purposes. The extent to which the artist accepts the constraints of existing technologies inversely determines the extent to which they will find themselves having to interact and collaborate with technologists of one sort or another in the realisation of the work.

To slightly modify Terveen's definition: "collaboration is a process in which two or more agents [here, people: artists and technologists] work together to achieve shared goals" [28] namely the production of an artwork, and this involves:

- Agreeing on the shared goal(s) to be achieved.
- Planning, allocation of responsibility, and coordination.
- Shared context.
- Communication.
- Adaptation and learning.

In other words collaboration involves primarily two things: interaction and communication, and requires that there be certain existing conditions, or that these develop early in the collaborative process; namely, shared knowledge and language, and a contract (agreement) of some sort that sets out procedure, intentions and ownership of the process and its outcomes. Importantly for successful collaboration, it also involves the willingness on the part of both sides in the process to learn and adapt to new data and conditions as they develop through that process.

Now, all of these criteria point very clearly to what I characterise as an enhanced cybernetic analysis of the process, which I will detail in the following section. In order to provide a generalisable underpinning of theory to the notion of collaboration we need to be able to accommodate the very wide range of interactions that can occur in that situation, and this needs to be rooted in what I call cultural systems theory so that we can see collaborative interactions as processes that take place over time. So it will be useful to draw from notions of interaction theory [13] as a function of cybernetic processes and from historical examples of collaborations, an approach to the understanding of collaboration as a cybernetic process within which we might then locate empirical information derived from actual collaborations and generate useful understandings of the process that could contribute to the enhancement of future collaborative processes.

2. SYSTEMS THEORIES AND ART

I will begin by taking a quick look at the development of art & technology as a way of introducing the cybernetics of the interactive processes of collaboration.

2.1 Systems aesthetics and cybernetics

Art & Technology, in the way that most of us would be thinking of it, namely as video and electronic art, digital art and interactive installation and performance work, begins perhaps with the Futurists in 1909 [17], followed after WWI by the Theremin [19] and Thomas Wilfred's Clavilux [16] over the middle third of the 20th century and reaches a certain zenith with the later Kineticists, such as Frank Malina [21, 3, 7], Takis [7, pp.127-130] and the early video artists, especially Nam June Paik [7, pp.146-152; 9], in the 1960s. At that stage it was theorised by Jack Burnham in his 1968 book Beyond Modern Sculpture [3, and see note 1] and an article in ArtForum [4] of the same year, in which he proposed a "systems esthetic" by which to analyse artworks that were more than simply objects, functioning in themselves as interactive systems. Systems esthetics refers to artworks that are based "on the creation of stable, on-going relationships between organic and non-organic systems" [4] of varying kinds, both social and technological. In the ArtForum article, Burnham defines the systems esthetic as such:

> "Inasmuch as a system may contain people, ideas, messages, atmospheric conditions, power sources, and so on, a system is, to quote the systems biologist, Ludwig von Bertalanffy, a "complex of components in interaction," comprised of material, energy, and information in various degrees of organization. In evaluating systems the artist is a perspectivist considering goals, boundaries, structure, input, output, and related activity inside and outside the system. Where the object almost always has a fixed shape and boundaries, the consistency of a system may be altered in time and space, its behavior determined both by external conditions and its mechanisms of control. … a system esthetic is literal in that all phases of the life cycle of a system are relevant. There is no end product that is primarily visual, nor does such an esthetic rely on a "visual" syntax. It resists functioning as an applied esthetic, but is revealed in the principles underlying the progressive reorganization of the natural environment." [4]

Burnham's view is strongly based on the concepts of cybernetics, which was developed by Norbert Wiener during and after WWII [31]. Wiener originally developed cybernetics to aid in the pointing of anti-aircraft guns during the war but he quickly recognised that it was applicable in many areas of machine control and analogous to the behaviour of animals and people in many ways. He saw that in many circumstances the control of some process necessitated a communications interaction mediated through a, potentially, complex and multi-layered structure of feedbacks between entities, both human and machine, that allowed the requirements of each to be taken into account in the regulation of the overall system in which they were embedded. However, while Burnham embraced the notion of these cybernetic relations operating between artist, object or presentation, and viewer, thus exploring the role of responsivity in the artwork, the actual role of the technologist is little mentioned, except in the fact that too many artworks failed for lack of ongoing technological support. [3, p.363] His one strong reference to the role of the technologist (engineer, mechanist, technician) is to the very important Experiments in Art and Technology (EAT) established by the Bell Labs engineer Billy Kluver and the artist Robert Rauschenberg [3, pp.359-363; 15]. This seminal American artist/engineering collaboration, Burnham notes, amounted to artists and engineers being "enmeshed with and within purposeful responsive systems" [3, p.363, his emphasis], placing the EAT project fairly and squarely in the purview of cybernetics and systems theory and, crucially, pointing to the need to utilise the systems framework in understanding the relationship between artist and technologist.

Elsewhere he notes that "The scope of a systems esthetic presumes that problems cannot be solved by a single technical solution, but must be attacked on a multileveled, interdisciplinary basis." [4, my emphasis] and it is here that the interaction between technologist and artist enters consideration. Architects, engineers and electronics technicians may all become involved in the production of a work (as they did with EAT and, later, eg, with Philippa Cullen [see Sect.3.2, below]), widening the network of ideas and influences that go into the production, and making the production more of a process, though Burnham does suggest that the artist may actually assume some of these functions.

Burnham recognised the role of the network of interacting individuals within a system and the functions of feedback and adaptation processes that go into developing an artwork using contemporary technologies, but he didn't explore the further consequences, which are that the interactions among those individuals are sequential, taking place over time, and that the relational ascendancies also vary over this time. In more general terms, a system is a network of nodes having disparate relations which change over time, so that at one interval one node is a source and at another a different node becomes the source, giving rise to opportunities for feedback relations to have a range of impacts both within the making of an artwork and within the greater society.

To a certain extent Burnham's analysis is incomplete because it fails to account for the potentially reciprocal interaction between the artist and the technologist. While his concern was with the role of cybernetics in the making of responsive artworks, the general thesis here is that this cybernetic activity is also what takes place between individuals, and between individuals and their institutions, in the processes of collaboration. It is this wider class of cybernetic coupling that provides the basis for my view of the relations between artists and their technical support and reciprocally the role of the artist in industrial and scientific institutions, with or without a collaboration in place. The technology makes available and the user makes demands, each feeding the other in reciprocity. There is a continual process of feedbacks (a conversation, so to speak) between the demands of the user -- artist or scientist -- and the engineer, the technologist. It goes something like this. Within some context the engineer develops the existing capabilities of a technology. These capabilities may stimulate the artist to utilize that technology for some process which suits their context and intentions, but the technology will be, almost necessarily, inadequate to the artist's intentions. It is here that the potential for collaboration appears. Even if it does not actually produce a collaboration, the needs of the artist can stimulate an engineer to extend the technology in some way thus extending the possibilities of its use, and thereby extending the range of the works that the artist might produce with that technology. Thus technology and art can co-evolve in a configuration of mutual interdependence driven by the feedback each supplies to the other, which is a cybernetic process, whether there is an active collaboration taking place or not.

2.2 Deleuze and Guattari's Machinic Phylum

While Burnham points to the value of collaboration (if only to keep the artwork running) and that it is a cybernetic system showing feedback distributed interaction, his model remains incomplete in that it doesn't elucidate the process by which collaboration evolves as a problem-solving mechanism. In order to reach towards this necessary extra layer in the interactions that constitute collaboration it will be useful to introduce Deleuze and Guattari's "machinic phylum", through which they provide us with a view of the dynamics or the motive forces in the cybernetic system.

In their "Balance Sheet Program for Desiring-Machines" [8] they consider our whole social process under the general rubric of the "desiring machine" as an aspect of their "machinic phylum". They invoke a cyclical interaction mechanism that is cybernetic and of a greater spread of function within society. [And what follows in this section is my extractive/interpolative reading of their article.] The machinic phylum must take hold of a tool so that

> "[The person] and the tool become or already are distinct components of a machine in relation to an effectively engineering agency (une instance effectivement machinisante). And we believe moreover that there are always machines that precede tools, always phyla that determine at a given moment which tools, which [people] will enter as machine components in the social system being considered." [8, pp.118-9, their emphasis]

The machinic phylum is seen not as the tools and machines that we use but as a dynamic network of technologies and people, a social machine that functions at that higher (societal) level. It is an organisation of functional nodes (people and institutions) in a social, collective network wherein the flow of energy and information produces the organisation of the machine (system) and drives its evolution. This social machine functions through communication and interaction, it is recurrent (ie, a feedback circuit), utilising "the probability of a less-probable" (ie, it produces order or new states of lower entropy, which is a definition of information [see note 2]); not "acting through the functional synthesis of a whole" but "through real distinctions in an ensemble" (as through the production of information by the system). In many ways it represents the linkages between people that make up a society. The motivational forces that flow through these linkages, producing the dynamics of the system, are the forces that Deleuze and Guattari gather under the rubric of "desire".

> "… desiring-machines are indeed the same as technical and social machines, but they are their unconscious, as it were: they manifest and mobilize [desires] that "correspond" to the conscious or preconscious [interests] of the economy, the politics and the technics of a specific social field." [8, p.132]

The players, the operatives in the machine are embedded in the machinic phylum as agents of desire.

> "Desiring-machines are not in our heads, in our imagination, they are inside the social and technical machines themselves. Our relationship with machines is not a relationship of invention or of imitation…. It is a relationship of peopling: we populate the social technical machines with desiring-machines, and we have no alternative. We are obliged to say at the same time: social machines are only conglomerates of desiring-machines under molar conditions that are historically determined; … [Desiring-machines] are eminently useful, since they constitute the two directions of the relationship between the machine and man, the communication of the two. …. you are already inside the machine, you are part of it…" [8, p.129, their emphasis]

Artists could almost be thought of as paradigmatic desiring-machines but for the fact that the desiring-machine exists at the more interactive social rather than individual level. Artists are often particularly difficult to pin down, artistic creativity being quite different from the more directed activity of the engineer. As Deleuze and Guattari note: "What defines desiring machines is precisely their capacity for an unlimited number of connections, in every sense and in all directions" [8, p.121].

They are or become rhizomatic, proliferating in the world as sequentially coupled interactions having impacts, in varied ways, on themselves and on each other as systems in process with other surrounding systems. The desiring machine is the ensemble of individuals and "fixed" entities (tools and machines in our usual way of speaking) the components of a constantly inter-looping collection of relations among components driven by our interests and desires and the tools' offerings. The desiring-machine stands apart from all representations, it is not the picture but the production and the reading of the picture -- under-coupled [see note 3] as these two will be, it is "in itself the production of organized intensive states: neither form nor extension, neither representation nor projection, but pure and recurrent intensities." [8, p.122]. Deleuze and Guattari consider the evolution of the phylum as process, as a continuum -- things take time to occur, to connect, and being multiple, things have varying time-states in relation to other components of the phylum, creating an overall context of many things in coupled relations with many other things. The types and qualities of relations are crucial; they are all and everything. Desire, generosity, multiple idiosyncratic behaviours drive the process, draw things in -- building the desiring machine. Components mutate producing a radical break as inventions. New approaches and discoveries energise the phylum. These breaks are step-functions in its processes (in its local and evolutionary time scales) and it shows a punctuated evolution -- flow-break-flow. It self-organises (as autopoeisis) as "a collective full body, the engineering agency on which the machine installs its connections and effects its ruptures." [8, p.121, their emphasis] Thus the collaborative process can be seen as this "machine" in itself, a machine that functions through multi-layered feedback processes operating between the individuals who are the "nodes" in the "network" that is the organisation of the machine.

Deleuze and Guattari's view clearly portrays the interactive function as it serves to bind individuals into productive processes, yet they do not then continue their analysis into the behaviour of these social machines, bound together through interaction, as "single" entities whole in themselves, which is what the team of individuals becomes when they are working on a common project. Within the machine we are engaged in construction -- we are engaged with the world in the process of its and our construction. To draw the process apart into components is ultimately to mislead because it is the one process of these components tightly coupled that is the world and our becoming in it. Nevertheless it is the driving force of desire that motivates the developments and innovations that produce technological developments and launch them into user-space, though this evolutionary process has its own trajectory.

2.3 Maturana and Varela's Autopoiesis

Regarding the machinic phylum, in our being within its process, Deleuze and Guattari's framework is a psychoanalysis of the behaviours (the desirings) of components in that whole, yet, as I have said, they do not consider the system as a bounded whole process. As a procedure for analysis, the concept of the coupled system (or network) that can be broken down into subsystems and their relationships for further analysis can be very useful. It is the way in which much science is done, even if the decoupling is unconscious and hidden from the investigator by their own structure of categories. Yet the subsystems must be re-assembled to gain an adequate understanding of the behaviour of the system as a whole.

The system of a collaboration in process entails layers of interaction and feedback and they are the object of interest here. It is the cybernetic processes in which the interactions within this structurally coupled system consist that bring forth its evolution. The concept of interaction that I am invoking here, in which the internal processes of the system (artist + technologist + the devices they produce and use) act to produce and reproduce its components, setting up a sustained existence for those components in the face of environmental perturbation, leads one to the concept of Autopoiesis. The theory of Autopoiesis was originally developed, by Chilean biologist Humberto Maturana and then extended in company with Francisco Varela, in an attempt to understand biological systems from the inside, rather than from the observer's outside view of the system. As a theory it describes the basis for self-organisation within biological systems and the cybernetic processes of the components of the system in play within that system. Although there is considerable debate as to the applicability of autopoiesis to social systems, [see note 4] many of the characteristics of autopoiesis assist greatly in understanding the development of the "components" (the term has a particular technical function) that would be operating in the social environments that produce the types of artifacts that, eg, make up the art & technology tool set.

Following Maturana [18], for a system of entities possessing a range of available relations, the structure of the environment within which it exists "provides the historical sequence of perturbations" [18, p.35] that select the trajectory of states that it goes through. That is, the kinds of processes (recurrent, continual, disruptive, etc) that the environment experiences determine the kinds of changes that the system, within that environment, undergoes. The environment itself may also be perturbed by the changes in the system, which then feed back into the behaviour of the system itself. If the organisation of the components of the system allows it to change structurally "as a result of its interactions" [18, p.35] then it is considered "structurally plastic" and it is "structurally coupled" if it is capable of undergoing "a domain of perturbations that allow it to operate recurrently in its medium without disintegration" [18, p.35] ie, if the system tends towards ultrastability, in Ashby's sense of being able to accommodate the perturbations through its range of possible "behaviours" [1, chapter 8].

Two or more autopoietic systems, say an artist and a technologist, each of which acts as a medium for the other, become mutually structurally coupled through the history of their reciprocal interactions. Events ("conducts", behaviours) in one system "triggering perturbations" in another system bring the systems into an interlocking of interactions which is indistinguishable from what we call a "consensual domain". "[A] consensual domain is closed with respect to the interlocking conducts that constitute it, but is open with respect to the organisms or systems that realize it." [18, p.47]. It is this "interlocked, mutually selecting, mutually triggering domain of state trajectories" [18, p.39] that is a collaboration, and I would consider that it is, in itself, an autopoiesis.

I consider a collaboration to be constituted of several participants who are coupled through their mutual interactions in a consensual domain (a domain of languaging). That is, a collaboration emerges out of the context of interactions among the components of a system. Each participant in the system may then influence the others through their varying capacities (affordances) for recognition and response, feedforward and feedback and, as Whitaker notes, "this influence is recursively exercised upon the emergent [collaboration] through the participants' ongoing interactions." [30, and see note 5] A collaboration maintains and continues its self-regulation through the productions that interactions among the participants of the system generate within it, as a result of the consensually determined potentials, eg, the range of the terminology (jargon) that is mutually recognised and understood, the willingness to subsume personal intentionality to the intentionality of the collaboration and other qualitative considerations that we will spend more time on in the sections on empirical data (Sect.5) and the discussion (Sect.6).

The determination of the consensual domain provides the boundary conditions (the conditions that determine whether an individual is a participant) through the range of terminological agreements that the members of the system have made. In this sense we can see that for individuals functioning in the vicinity of the system, one is either an insider or an outsider. The insider is the one who is going to have the influence except under extraordinary circumstances and then the system will include the outsider by, itself, adapting to the new terminological domain that they bring with them. Again, here is where the artist can have a very strong role, as a disrupter of standardised views and as a generator of new productions, which in turn may produce new demands on the tool use structure of the system.

2.4 Towards a cultural systems theory

On the basis of the above, we can think of collaboration in this way: the creation of a device or an artwork through a spiraling evolution brought about by the interactions of collaborators within an integrated system of feedforwards (being suggestions or enquiries), feedbacks (being responses) and adaptations. For those outside the collaboration, it would be seen as a self-generating autopoietic process.

A collaboration may develop when two or more people involved in some sort of interaction about a project decide (make an agreement) that their combined activity, the interactions, constituted of their independent skills can be brought together to solve a problem brought by one or both of them. In the case of an artistic collaboration this will be drawn from the intentions of the artist and in the case of a technical development this will be drawn from the intentions of the technologist towards the development of a technology, program, process or device.

The individuals involved should be seen as discrete autopoieses that engage in feedback processes which bring a potential integration of the interests, intentions and skills of the individuals into what is a "desiring machine" or system. The particular desiring machine is driven by the needs, desires, intentions and imaginations of the individual autopoietic entities within it. As a system it will, in the whole, be autopoietic, operating in a substratum of the consensual domain that we understand to be a society, and, in its construction as a jointly agreed project, becomes, in itself, a more narrowly determined consensual domain which is, thus, the collaboration. [see Fig.1]

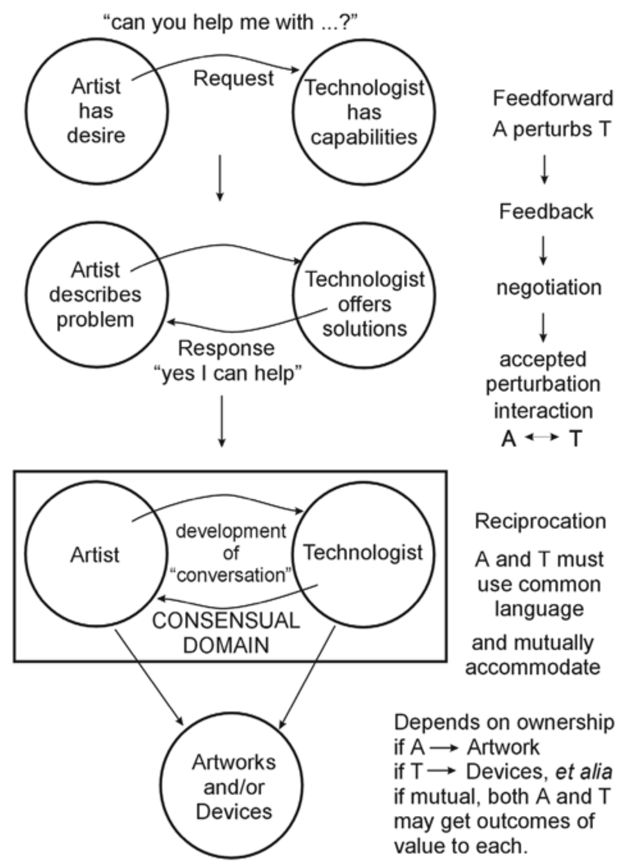

Figure 1: Indicating the stages that a collaboration goes through in the process of its development. The circles represent autopoietic entities and the box represents the collaboration as an autopoietic process in itself. Lines running between the entities represent interactions as communications, mostly feedbacks.

The approach I have taken here of generalising the evolution of a collaboration over the cybernetic framework is that the varieties of the cybernetic framework and the recognition of the levels of integration of the entities involved and the dynamics of ascendancy that may occur through the period of the collaboration are all behaviours of autopoietic systems. For any autopoiesis, the motivations of which are described by the desiring machine, we can see that there is a spectrum of possible forms that the collaborative process can assume and that all of these are bound by certain similar processes, namely

- intentions
- agreements
- systems of feedback
- common language leading to a consensual domain
- suspension of private ownership
- willingness to adapt and learn

One of the advantages of considering individuals and consensual groupings (systems of individuals such as collaborations) as autopoietic is that it acknowledges that the kinds of changes (adaptation, learning) that the system or the individuals may undergo due to perturbation from feedbacks and other events is that the entity has to make the accommodation from within its own framework. The perturbation doesn't make the change. If the entity is capable of recognising the perturbation and has internal means for accommodating it, by making internal changes, then it can be said to have adapted. If it is unable to recognise that perturbations are occurring then it will not be able to initiate internal changes (adapt) and the system may well begin to unravel, especially if the perturbation represents a need in one of the members of the collaboration to instill changes into the other.

3. HISTORICAL COLLABORATIONS

I will now look briefly at two historical collaborations that occurred in Australia in the early 1970s.

3.1 Doug Richardson and the Visual Piano

In 1968, the head of the Basser Department of Computer Science at the University of Sydney, Professor John Bennett returned from a trip to the UK where he had presented a paper on the networking of the department's computers at IFIP'68 (in Edinburgh). Several papers on computer graphics and art were presented at IFIP'68, particularly one by Leslie Mezei, who had been developing graphics software for artists in Toronto, Canada [20]. During this trip Bennett had also seen the Cybernetic Serendipity [23] exhibition at the ICA in London and he recognised that it would be a good idea if computing students and artists in Australia could have access to a computer art facility. He gave several lectures [2] in Sydney on the computer art he had seen in London and elsewhere on his trip and then with the help of Donald Brook, who was a lecturer in art theory at the Fine Arts Department of the University, invited a number of artists active in Sydney at the time (circa 1969) to try out the computer system at the university to explore the possibilities of making art with it. At this stage it was used primarily for data reduction in scientific work and to teach programming. There were no available graphics software packages in Australia and apart from the occasional banner or calendar there was little graphics production. One of the senior students, Doug Richardson, had been producing mathematically generated images from the computer and he was asked to demonstrate it and the plotter to those artists who expressed an interest. However they all found it a completely intractable proposition because the procedures required to write computer software (viz, unforgiving logical consistency) were utterly alien to the procedures required to make paintings or sculpture (viz, tactility and the expression of feeling). So Bennett asked Richardson to develop a software system that would allow artists to work with the department's PDP8 computer in the production of computer art. He spent some time talking with artists about what it was that they thought they would need and then set about trying to develop it.

> "With [their] problems in mind, I set down the basic tenets that I felt a computing system would require in order that artists would want to use it as a tool. The most important are that the output must be interesting, modifiable, and immediate. The system should, ideally, be simple enough to use so that computer programming training is not necessary. It was also apparent that the computer should be used only to fulfill functions to which it was best suited. It seemed redundant to produce software to perform tasks that could be done better using other techniques." [24]

Richardson produced a system he called the Visual Piano which allowed artists to draw 3D wire-frame objects in real-time using a light pen on the screen surface. The objects could then be given motion by using the light pen or by injecting audio waveforms from a synthesiser into the Analogue-to-Digital Converter that had been added to the computer. A number of artists and video-makers used the system which ran for several years producing a variety of animated film and line drawn graphics that were photographed on the screen and then displayed as large film transparencies on backing paper. There were two exhibitions of work made on the system before it was damaged in a fire in the caused by a failed fan bearing in the computer. [11]

This was really a very loose form of collaboration, more almost a process of consultation and then going away to implement and then returning to have the implementation tested by other artists. The artists who used the system functioned for Richardson as testers and as sources of ideas and desires that stimulated his development work. Although each relationship with the artists was a collaboration, since it was not really possible for the artists to operate the system without his help, it was the complete series of interactions that form the real substance of the collaboration and through which the resulting object (the computer software package) and the artworks were produced.

3.2 Philippa Cullen and the theremin.

Philippa Cullen, was an arts student at the University of Sydney and a dancer. She had been interested in the problem of finding a means for dancers to generate their own music directly from the dance. In 1969 she saw an interactive installation work in the Fine Arts Workshop at the University that used a theremin with a long wire aerial and made sounds and Lissajous patterns on a TV screen that changed as the audience moved near the aerial. It was produced by David Smith, an electrical engineering student who was interested in art, and Cullen realised that this system could be of value to her. She then worked with Smith to produce a ballet in which a number of dancers worked among a triangular shaped aerial set up across the stage to produce the sounds, here the basic sine-wave sounds of the theremin. The ballet, Electronic Aspects, was performed at the University in 1970.

Cullen was not satisfied with the results and she wanted to develop the concept further. However, in 1971 Smith went to live in France, so she had to find new technical people to work with. During 1971 she gathered a small team to further develop the theremin as an instrument that dancers could use. This group consisted of several dancers plus an architecture student, Manuel Nobleza, with whom Cullen designed a range of aerials, an electrical engineering student, Phil Connor, who designed a theremin output which could give voltage signals that were proportional to the audio frequency output, and a composition student Greg Schiemer who used these control voltages to control the sounds produced by a VCS3 synthesiser. They produced a second ballet Homage to Theremin II in July 1972. Cullen then went on to study electronics herself and engaged in other collaborations in interactive dance until July 1975 when she unfortunately died while traveling in India. [12]

With her works, in all cases, Cullen very much owned the outcome, which was the ballet, however each of the individual technologists retained ownership of the technical devices they developed for her use. They were then able to go on to use those devices in other work of their own. Again we have a multiform collaboration that is open enough for each person involved to take their own direction while at the same time focused enough to produce the important results sought after by Cullen as the owner of the project. Both the electronic engineer (Connor) and the composer (Schiemer) then went on to develop significant works of their own and also in collaboration, producing both electronic musical instruments and compositions with them.

4. PERSONAL EXPERIENCE

My own professional career is as both an artist and as a technologist. As a technologist I have worked with other artists in both the roles of partner and of assistant (as defined in Candy [5]). As an artist I have assumed both roles myself, since most of my work has been, in one way or another, in video art and art & technology. It has been my observation that the ownership of the work and the available funding support for its production are the crucial criteria that determine what kind of role one has to take. For example in my art practice I have been almost entirely unable to work in collaboration with a technologist, not because of any lack of willingness but simply because I have not been able to pay them or otherwise had access to some sort of institutional framework in which they are paid.

In my experience as a technologist supporting other artists, where I have had institutional engagement, for example when I worked at ATR in Japan building interactive display systems for Christa Sommerer and Laurent Mignonneau [27], the situation was that as an employee of the institution I was expected to work essentially as an assistant even though in many ways that assistance was in the process of mutually developing solutions for technical problems contained within the artistic production, but as the artists owned the works my assistance amounted to suggesting solutions and then, after they had been discussed, to implement the solution that resulted from that interaction.

In situations where the interaction has been as a partnership, for example in my years with the electronic music band Severed Heads [26], the level of partner versus assistant varied on a task-by-task basis so that over a long period of collaboration I found myself sometimes directing the process and at other times being the assistant. Two things made this fluidity possible. One was that everybody involved, in any particular project (essentially the production of video clips and live video performance with the band) was willing to allow the others to have a significant say in the process. In other words we each together owned the work. The other was that the work being engaged in was entirely supported by my private company, the video post-production facility Heuristic Video, on the basis of other commercial work that it carried out. This way the problem of financial support rarely entered into the game.

In another situation, working with the Australian new-media artist, Rea [22], who in coming to me with a fully worked out project owned the work, we nevertheless had a mutually satisfactory partnership in terms of coming up with solutions to the technical problems of making the desired interactivity work. These solutions involved both the development of new technologies for the interactive control of DVD players [14] and the determining of video production and DVD authoring procedures that made the interactive technology feasible. In this situation the technology was developed around the artist's intentions in designing the installation, which in turn were partially influenced by the technological possibilities that I as technical designer could offer, thus a true co-evolution of the work occurred.

5. EMPIRICAL WORK

An investigation of artist/technologist collaboration was carried out by Candy [5]. Observations of a series of collaborations between artists working with digital media and technologists on staff or accessible within the university, housed at the Creativity and Cognition Research Studios (C&CRS) at Loughborough University in the UK, were used to gather information about how collaborations might best serve in

> "researching innovative forms in art practice and facilitating that practice by enabling artists to work in a technical and physical environment not normally available to them. The goal [was] to enable new digital artwork to be developed and to study both the implications for art practice and future technologies. In addition, a key area [was] to understand the requirements for support structures for creative practitioners." [5]

The collaborations were observed and then rated on the basis of

- Cognitive style: which covered matters of ownership or control over the project, roles to be adopted and methods to be used

- Knowledge: which included things like knowledge of the domain, technical skills and research knowledge and the type of inter-dependence shown.

- Communication: which included things like mutual understandability of the language used (eg. that it is not overly technical or jargon filled), the history and openness of the relationship and the ease with which ideas can be exchanged.

Candy identifies two main types of collaboration: partnership and assistance. In partnership, while the focus is on the joint project each of the members of the partnership retain ownership of their own contributions, while at the same time relinquishing control over those contributions within the domain of the project. Also as Candy notes: "having differential but complementary roles appears to be best suited to achieving" [5] the intended result. The assistant model is more one-sided, ownership of the project usually belongs to the artist and the technologist may feel that they are not getting any benefit from the project (other than to be paid) unless there are other benefits to be had such as developments in technology that they can take away with them once the collaboration is finished. The artist may also feel that they are not getting much from the arrangement except perhaps when they are able to learn some new process or technology that the technologist brings to the table. In the partnership "knowledge sharing is beneficial" [5] and the artist may find that this enhances their options in developing the work. In either approach the advantage for the artist is that they get the credit for the design of the artwork, which may be the most important thing for them.

The quality and ease of communications is also important and is likely to influence the effectiveness of both the partnership and assistance approaches. As Candy suggests:

> "A high degree of openness and flexibility and a willingness to engage fully in all available communication paths facilitates the partnership model of creative collaboration. A lack of flexibility possibly stems from a difference in perception about the nature of creative process."[5]

Lack of mutual respect in the capabilities of each and lack of a common language within which to discuss the project will also lessen the effectiveness of the collaboration, tending to reduce the relationship from partnership to mere provision of assistance.

Candy suggests that the development of a "common understanding" is the most valuable process in developing the collaboration. This can be readily seen in the systems theory structure I have set up as the function of higher level feedback processes that operate between autopoietic entities in the establishment of a consensual domain so that the whole collaboration itself becomes autopoietic and thus able to sustain itself in an environment where various difficulties (perturbations) may arise such as the appearance of un-anticipated technical problems or other outside social issues.

Finally it is crucial to note that in the C&CRS project the artists were brought in on residencies and the technologists were already on staff at the university. Thus there were no inherent inequities about payment for consulting time for example. This would have made the potential for a partnership arrangement considerably easier.

6. DISCUSSION AND CONCLUSIONS

It can be seen from the spectrum of collaborations I have mentioned here that the overall concept of collaboration has a wide range of possible implementations. The cybernetic and autopoietic systems structure that I have outlined shows a wide range of possible interactive processes are available while still retaining some sort of collaboration between individuals within different disciplines

The development of this cultural systems theory of collaboration allows us to see that the internal structure of any particular collaboration is dynamic, operating according to the feedback systems covered under the rubric of cybernetics, and ultimately that all organisation is dynamic. The entities that engage in the interaction are drawn together through a range of needs, desires and intentions and the system (the desiring machine) that develops from these motivations, itself maintains that organisation through a process of feedbacks that bind the individuals into a single process; the collaboration. Each of the entities is an autopoiesis itself and as such goes through a continual process of feedbacks to maintain its internal condition.

Because each of the individuals within the collaboration are each separate autopoietic entities for whom the other is effectively only a privileged source of perturbation, they will each own the productions of their contribution to the overall process, unless that is explicitly ruled out in the contract or agreement that has been made, and since in most artistic collaborations such an agreement is not made it could be fairly safely assumed that each person will walk away with some level of ownership over what they personally developed. For example this definitely happened with the Philippa Cullen collaboration because the engineer and the composer both went on to use the devices and techniques developed for Cullen in other subsequent projects of their own.

In the Visual Piano project the technologist, Richardson, owned the project though he took much of his direction, the kinds of goals desired and the feedback leading to adaptation from the artists with whom he worked. Ultimately Richardson himself morphed into an artist and had several joint exhibitions of the work he did with at least one of the artists he worked with resulting from the series of collaborations. In a somewhat grander collaboration he brought together most of the artists and technologists working with electronics and computers in the arts (including Philippa Cullen and her team) into a major exhibition called Computers and Electronics in the Arts, at the arts festival Australia 75 held in Canberra, in March, 1975 [10, 11].

The interdependence of the collaborating individuals is a crucial issue, and will vary on the basis of a variety of factors, including how much the artist understands the technical processes required to achieve the outcome, how much room they are willing to give, how much the technologist is able to implement solutions without reference to the design aspects of the work etc. The interdependence factor will vary considerably for each collaboration due to the personalities involved, the types of technologies involved, the nature and scale of the artwork

One of the things that doesn't really enter into much discussion of collaboration, in that most research into it implicitly assumes that each member of the collaboration should be supported by the institution carrying out the research, is the cost of the time given over to the collaboration for the individual (usually the technologist) who does not own the project outcome and who does not necessarily get paid. Proper payment is essential, both in the partnership and in an assistance-provision collaboration if the collaboration is going to work and not be a straight out exploitation, something that definitely does happen and is often accidentally encouraged by inadequate arts funding. Fortunately this does not always apply as many artists these days use contract labour to produce the work, especially in the larger installation and sculptural works and public art. Of course these are not really collaborations at all. The contractors are usually paid and they are rarely credited.

Nevertheless, for many technical people it is also very important that artists who work in collaborations recognise that they have to provide proper crediting of those who helped them realise the work. This is often not accorded and can be a very grave problem for the technologists who work in the arts as they may well be depending on the credit for their own reputation to develop so that they can get that next job. Remember the adage that applies so strongly in the film and television production industry: "you are only as good as your last job."

In conclusion: I have set out what I describe as a cultural systems theory of collaboration that derives from cybernetics and its expansions. This theoretical substratum shows how collaborations can have widely varying forms while still retaining a similar set of dynamics that bind them together so that results are achieved. I have mentioned several historical and personally experienced collaborations to illustrate this variety and have canvassed some of the empirical work that has been done. It is clear that a partnership makes for a far more rewarding collaborative process, but assistance and partnership belong on a continuum and even within the one collaboration the interaction may range over this continuum at different stages of the process.

NOTES

1. In Beyond Modern Sculpture [3] Burnham provides a very thorough look at the history of sculpture that attempts, starting with automata, to engage some sort of mobility and programmed activity, that works with light and of the early electronic and truly cybernetic (responsive) work in Europe and the US up to the mid 60s. To some extent he discusses the collaborations that went into many of these works.

2. Wiener: "information … grows when the a priori prob-ability of the pattern or a time series diminishes." [Wiener: Human Use of Human Beings. p.7.]

3. In which the nature of the coupling is under-determined, loosely coupled, and capable of much change.

4. The main problem is that autopoiesis supposes the presence of a boundary or membrane that contains the components and which prevents the exchange of information or components across that boundary. The presence of some kind of molecule that is brought in from outside is, as far as Maturana's autopoietics is concerned, impossible. All it can "know" is the presence of some molecule within its bounded region and anything that happened outside is irrelevant as far as the system is concerned. Maturana has been prepared to consider social systems as autopoietic and has explored the construction of consensual domains and language [18], whereas Varela argues that the lack of a boundary in social systems and consensual domains indicates autonomy but not autopoiesis [29]. My view of this issue is that in fact within the construction of consensual domains boundaries exist and function to include or exclude "components", ie, members of some group, from the consensual domain so that if one doe not understand the jargon involved then one is left outside the domain, though of course other factors may attract outsiders into the domain on the basis of other criteria such as the capacity to make highly original suggestions, a function which will come to the fore throughout the early days of the art & technology activity and may well extend to being a primary role of the artist.

5. Whitaker is referring to Maturana, H. (1980) "Man and Society", in Benseler, F., P. Hejl, and W. Kock (eds.) (1980) Autopoiesis, Communication, and Society: The Theory of Autopoietic Systems in the Social Sciences, Frankfurt: Campus Verlag, 1980. pp. 11-32.

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