From System to Software:
Computer Programming and the Death of Constructivist Art

Richard Wright, October 2005.

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"Today we stand between a society that does not need us and one that does not yet exist."
El Lissitzky,Theo Van Doesburg and Hans Richter, "Statement by the International Faction of Constructivists", 1922 [1].

History has not been kind to the Constructivists. Unlike the other big hitters of the Modern art movement, they have almost become figures of fun in art history – the first artist geeks with their rulers and protractors, polishing their little Perspex maquettes and planning their rectangular utopias. One can still find artists who feel an affinity with Surrealism's uncovering of the irrational, designers who take inspiration from Cubism's fragmentation of space or radical intellectuals that find a precedent in the anarchic interventions of Dada. But it seems as though Constructivism has been unable to maintain its relevance to British artists since the end of the seventies, its enthusiasm for science and engineering superseded up by the rise of mass digital computing and telecommunications. In fact it feels as though Constructivism has become a victim of a kind of success story. Many of Constructivism's core values of collaborative working and research, of objective process as opposed to subjective meaning and deference to the machine as a source of artistic inspiration have now been absorbed into the assumptions of current new media art practices and funding strategies in the UK.

Constructivist art was an art built not on technology but on technique - on definable and reproducible creative acts. Its historical development has taken it through the machine aesthetic of the Russian pioneers, the semiotic systems of the post war Germanic artists, the cybernetics of the English and North American groups and finally to the conceptually minded systems artists of the seventies who tried to capture and harness a single thought as the starting point for a constructive process. If we accept that this idea of the 'programmatic' – the recasting of artistic work into an objective, reproducible discipline – was a central tenet in Constructivism then it is a little hard to see why the movement should have declined precisely at the point at which the 'programmatic' seemed to reach its fullest potential for expression - the programming of the digital computer.

Why did Constructivists find it so hard to switch from calculators and graph paper to BASIC and PCs? Was something lost when programmatic ways of working became wholly identified with the control structures of digital processing? Was there something in the wider context of the programmatic that did not readily transfer to computer programming – something that could now be recovered and used to refresh current software based art practices that constantly struggle with the limited imagination of proprietary operating systems, desktop interfaces and network protocols.

The First Rise and Fall of Constructivism

The constructive approach is an aesthetic and a technique comparable to montage as one of the main driving forces behind avant-garde art. Montage values fragmentation, conflict, the staccato rhythm of the machine and opposes continuity and organic unity. Construction values openness, clarity and the structuring process in opposition to predetermined content, completeness and individual subjectivity. Yet at various periods these very structuring principles have threatened to become a new form of idealised content, close down the depth of its enquiry into a rigid functionalism or in contrast lose direction altogether and become the generator of empty optical effects.

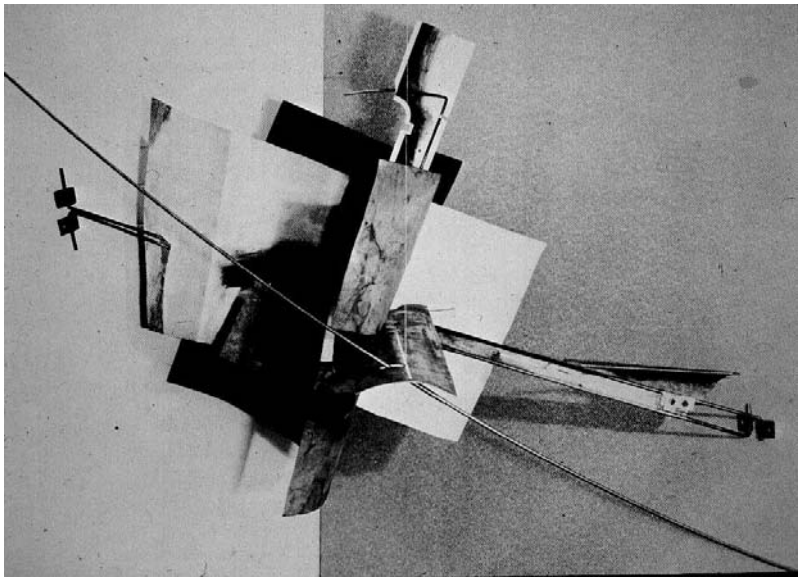


Fig. 1. Vladimir Tatlin, *Corner Counter Relief*. Mixed media, Petrograd, 1914-15. (Destroyed, photo: Taurgo).

It was at "The Congress of International Progressive Artists" in Dusseldorf in 1922, that El Lissitsky, Theo Van Doesburg and Hans Richter issued a joint statement in protest at its conservatism entitled "Statement by the International Faction of Constructivists". This was the first time that a central set of concerns were identified under the name of Constructivism. Significant is the fact that it was signed by Lissitsky representing the functional Russian constructivists, Van Doesburg representing the aesthete De Stijl group and Richter representing the Dadaists. One passage in the statement sums up the basis of their shared interests succinctly – their opposition to the "tyranny of the subjective" and "lyrical arbitrariness" and their belief in the "systematisation of the means of expression to produce results that are universally comprehensible" [2]. Right here we can already see the close relation between order and chaos as existential phenomena of the objective world, and the root of a productive tension between construction and destruction, progressive Constructivism and anarchic Dadaism that formed the twin poles of modern arts new role in the world. At the same time, the phrase "systematisation of the means of expression" gives us the central technique by which the new movement would seek to exercise this role. Its artistic inspiration could be traced back to a work exhibited seven years previously in Petrograd – Vladimir Tatlin's sculpture known as the "Corner Counter Relief" of 1915 [Fig. 1]. Tatlin's sculpture was both a development of Picaso's Cubist fragmentation of space as an aesthetic and also an 'opening up' of the previously unified technique of art making into a series of manufacturing operations. In this work not only did he 'return to reality' by including real industrial materials like synthetic Cubism had but also 'returned' art to everyday activity by making it possible for the audience to discern how one might go about making ones own relief sculpture from bits of tin sheeting, wooden laminates, rods and bolts. This explains an important sense in which a "systematic means of expression" could lead to those "universally comprehensible" results – as though it were an IKEA flat pack wardrobe complete with instruction book and a set of allen keys.

Equally relevant in the "Corner Counter Relief" was Tatlin's decision to build the work across the corner of the exhibition space, a design that built it into a structural feature of its physical environment. It presaged a central ambition of the Russian avant-garde – to have their art recognised as being able to make an aesthetic and a utilitarian contribution to the building of socialist society during the twenties. Along with El Lissitsky and Alexander Rodchenko, Tatlin laboured to demonstrate a role for art whose aesthetic values were not above the sensibilities of the proletariat and the commissars and whose awareness of constructive possibilities could guide the bureaucrats who were implementing social policy – to inspire the rebuilding of society through their "creative processing of practical materials" as the critic Boris Arvatov had put it [3]. But by 1922 their influence was already fading in the face of hardening attitudes to the conflicting aims of social engineering and artistic experimentation. Over the next ten years the Russian Constructivists were to learn that Soviet politics is about control, not experimentation. By the nineteen thirties the avant-garde artists that had remained in Russia had been forced to turn their skills solely to the promotion of Soviet restructuring or else flee from the threat of the Gulags.

Two Russians who had always remained sceptical that the social role of Constructivism lay in its industrial utility were the brothers Naum Gabo and Antoine Pevsner. After publishing their aptly named “Realistic Manifesto” in 1922 [4], they both left Moscow never to return. Gabo reached England in 1936 and with the encouragement of Ben Nicholson and Barbara Hepworth, married and settled for a while with a growing community of modern artists at St. Ives in Cornwall. Along with other émigrés like Moholy Nagy and Piet Mondrian, Gabo exerted great influence in bringing to this backward country the ideas of Abstraction in general and of Constructivism in particular until he left for the United States after the war.

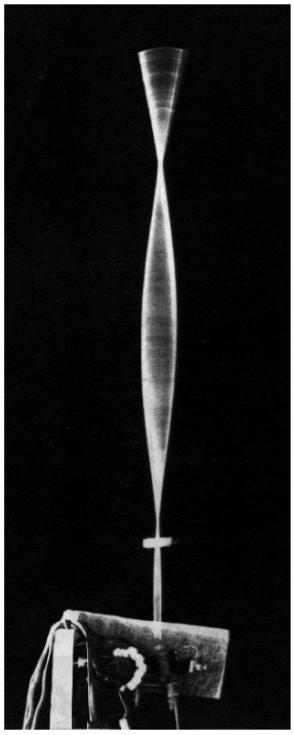


Fig. 2. Naum Gabo, *Kinetic Sculpture (Standing Wave)*. Metal, painted wood and electrical mechanism, 616 x 241 x 190 mm, 1919-20.

Of particular significance for us in this early period is Gabo’s seminal “Kinetic Sculpture” of 1920, consisting of nothing more than the shape made by a vibrating wire powered by an electric motor [Fig 2]. This work expanded the Constructivists desire to open up the artwork in visual terms, yet at the same time introduced an apparent contradiction in technique that systematic art was to return to in various guises again and again. Through its rapid oscillations, a vertical wire generates the image of a ‘standing wave’, a perceived physical space yet one without physical mass or solid boundary. At once this work was able to demonstrate not only the dependence of physical form on structure, time and motion, but also its construction as an intangible image in the mind of the observer. Yet this was not pursued by Gabo, who quickly returned to static constructions and the engineering of industrial materials. He described his reasons for pulling back from the further employment of electronics and machines in an article for “Circle: International Survey of Constructivist Art” in 1937. He spoke of his fear of “killing through mechanical parts the pure sculptural content” [5], as though the point of his constructivism had to be what could be expressed through the visual form of the entire work. For Gabo, a kinetic sculpture would at least have to be separated from the distracting appearance of its underlying engine, cogs, coils and capacitors. Unlike the open construction of Tatlin’s reliefs, Gabo could just not see how you could open up the construction of things like electric motors and still meet the aims of an art based on the visual knowledge of physical forces. A bunch of electrical parts soldered together just did not express anything. It was the first recorded instance of what would later become known as the Black Box syndrome.

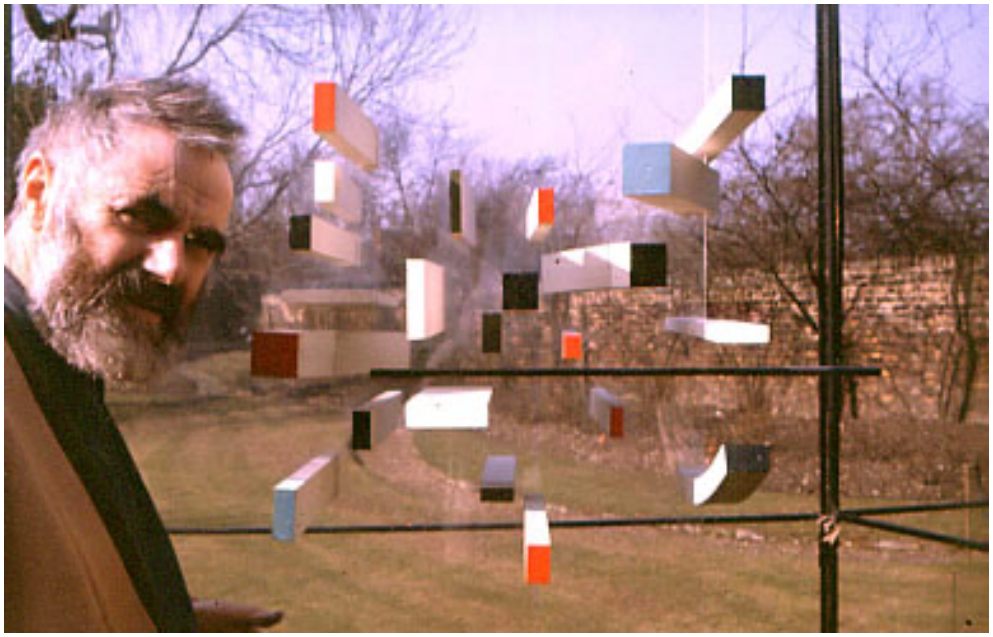


Fig. 3. Victor Pasmore and *Hanging Relief*, 1965.

The influence of the Constructivist refugees in England did not come to full fruition until after the Second World War. It began in 1948 when Victor Pasmore, a successful figurative painter, shocked his patrons by announcing his complete conversion to abstraction. In contrast to other forms of abstraction which were based on abstracting from the visual appearance of the natural world, Pasmore emphasised an art that originated at the level of abstract creation itself. Later in 1967 he wrote of this need to search for a new artistic premise "…concentrating on the nature of objects and processes as 'things in themselves' whether they be a sheet of paper, a blot of colour, the mark of a tool, the movement of the hand or the motion of a machine" [6] [Fig. 3]. Pasmore meant this art to be founded not on the idealised meaning of visual elements as religiously motivated artists like Piet Mondrian and the Christian Scientist Ben Nicholson had intended, but 'existentially' on the properties of material things and 'what they may become'. The surest way to rid non materialistic illusions from ones art was to reject the plastic idealism of the flat surface entirely and Pasmore added his voice to the call to turn to the physical reality of the constructed relief.

By 1951 Pasmore had been joined by artists such as Kenneth and Mary Martin, Adrian Heath and a young ex-student of his called Anthony Hill. Straight away they felt the need to differentiate themselves from the concerns of the previous generation by calling themselves 'Constructionists'. They were not engineers like Gabo nor were they believers in the pure emotional qualities of pictorial form like Mondrian's Neo-Plasticism or Malevich's Suprematism. It was during this search for a new direction and identity that the young Anthony Hill emerged as the chief theorist of the group and started corresponding with three very different influences from outside these shores – the Swiss Concrete artist Max Bill, the American Structuralist Charles Biederman and the spiritual father of conceptualism Marcel Duchamp.

In 1948 Charles Biederman self published his magnus opus "Art as the Evolution of Visual Knowledge" [7]. Biederman presented the history of art as the history of the analysis of the natural world in visual terms. The main turning point in this history was in 1917 when Piet Mondrian painted the first full geometrical abstraction. This achievement was the signal that artists could now turn their attention away from the appearance of nature and towards the "structural process level of nature". "In the past the artist 'imitated' the RESULTS of nature-art; today the new artist 'imitates' the METHODS of nature-art". But like Tatlin before him, Biederman's preferred methods were actually quite intuitive, believing that mathematical approaches were idealist and would cut off creative development from the external inspiration of nature. In fact what Biederman really meant by 'visual knowledge' was a form of realism in the tradition of Leonardo, a perception informed by scientific knowledge and directed towards a communion with the natural world.

Eventually Biederman's identification of objective processes with processes 'natural' in origin proved to be an artificial and restrictive distinction. Anthony Hill certainly considered the theoretical products of abstract logic to be just as real as anything in nature and became drawn to the mathematical work of the Swiss Concrete artists Max Bill and Richard Lohse. Their use of mathematics had moved away from the metrical relationships and geometrical proportions of the pre-war period to a level that was no longer tied to the visual world, "The mathematical approach in contemporary art is not mathematics in itself… It is primarily a use of processes of logical thought towards the plastic of rhythms and relationships" [8]. It was this that gave the Swiss artists the theoretical justification to move from constructed reliefs back to painting. An intangible mathematical object has as much validity in two dimensions as in three.

During the fifties Hill began thinking in terms of three materialities in art – the physical properties of the art object itself (which formed the raw materials for early Constructivists), its perceptual properties (which underscored the aims of Van Doesburg's Neo-Plasticism) and something he called its "thematics of construction" [9]. By taking a definition of mathematics as the "theoretical phenomenology of structure", Hill sought to find a new place for an abstract formal language in art by fusing it into the structural process of creative thought itself, including the artist's physical and perceptual sensibilities.

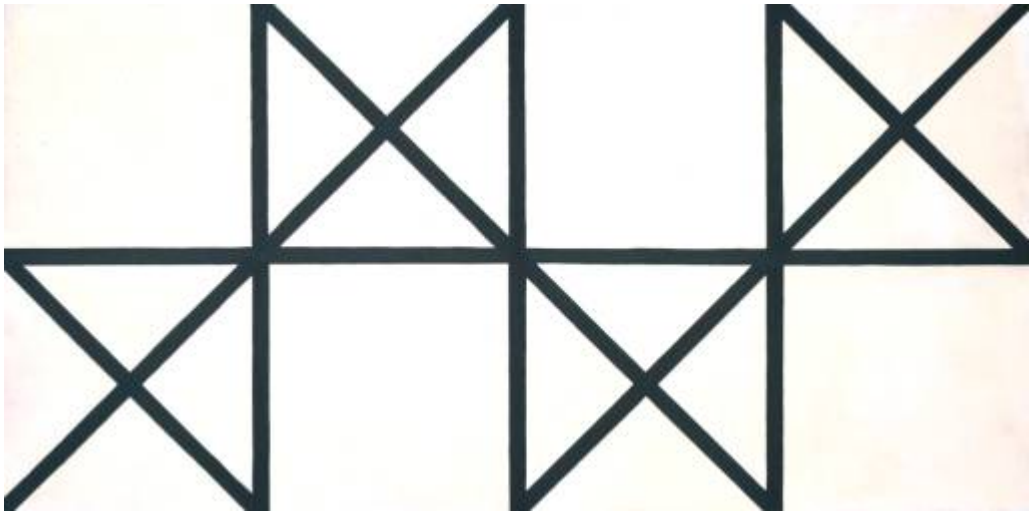


Fig. 4. Anthony Hill, *Orthogonal/Diagonal.* House paint on canvas, 606 x 1216 mm, 1954 (Tate Gallery, London).

If we look at two works produced during this period we can see some of the ways in which Anthony Hill and his contemporaries developed the role of rational methods and paved the way for the subsequent generation of English Constructivists. In 1954 Hill painted "Orthogonal/Diagonal Composition" [Fig. 4]. It consisted of a four by two arrangement of white squares with the alternate squares separated by thick black orthogonal lines and criss-crossed by thick black diagonal lines. This austere looking grid betrayed none of the classical concerns for harmony and balance that Mondrian strove for – it simply was what it was. Later, Hill cited Duchamp as an influence in this work in that it could be described as a "geometrical readymade" [10]. For Hill, this work represented the appropriation of a mathematical object for an artistic purpose. Unlike Duchamp's urinals, mathematical objects have no sensory existence in themselves. Yet although they are primarily theoretical objects, a square tessellation seemed to have at least a historical reliance on visual perception, as when the Greeks first studied them in geometrical diagrams to prove their theorems. After all, if no one had ever drawn a square, would it still have been possible to imagine one in purely theoretical terms? The square's visual instantiation had been necessary to the development of mathematical thought even though its visual properties had since come to be seen as derived from mathematical structure.

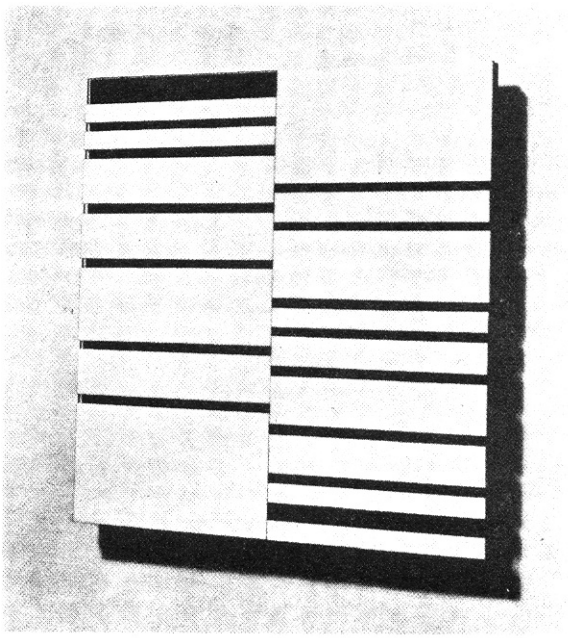


Fig. 5. Anthony Hill, *Prime Rhythms (Constructional Relief).* Perspex and vinyl sheet, 1958-60. (Coll. Adrian Heath, Clio Heath)

In “Prime Rhythms”, a low monochrome relief constructed in 1958, Hill had moved away from the mathematical object as such and towards mathematical ‘themes’ [Fig 5]. By ‘theme’, Hill was referring not to the subject of the work but to its starting point at the level of formative structural processes. In this particular work, Hill took all the prime numbers less than one hundred as his “thematic idea” and used them in a succession of what he termed “structural modifications” [11]. This consisted of operations such as throwing out all the even numbers, selecting only consecutive primes and then a whole myriad of systematic procedures based on “distribution, deviation and density ratios, equalities and inequalities”. These were always derived with reference to the visual properties of the relief such as the use of planar intervals in order to embed the sequence in the form of two sets of horizontal bands. It is clear that during the making of this work Hill developed quite an appetite for and familiarity with the pattern of primeness, yet he was at pains to point out that the work was not about the prime numbers as such. It was simply about what you saw when you looked at the relief, a particular visual rhythm, prime numbers forming the “idea in the work as opposed to the idea of the work”. As to the significance of the procedures that he applied to this idea, “Certainly other procedures could have been found to achieve the same sort of end, but the satisfaction of the one chosen lies for me in the fact that it had to be worked on and did not involve chance or ‘aesthetic trial and error’ at every level, nor did it carry with it some notion of finite ideal order”. It was in this way of ‘working on’ objectively defined qualities and operations that Hill and others were developing a practice that was removing the distinction between visual invention and mathematical investigations.

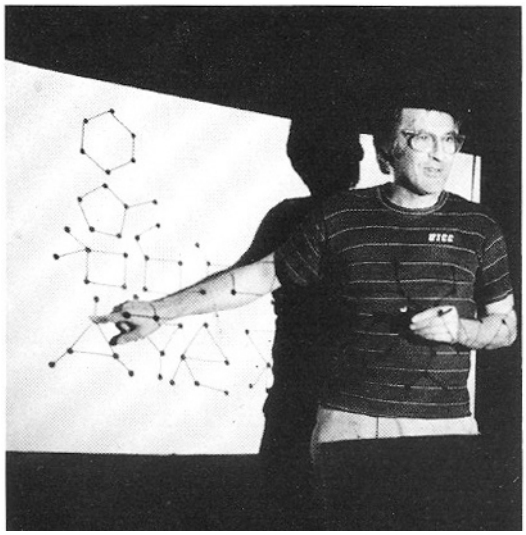


Fig. 6. Anthony Hill, 1976 (photo: Jerome Ducrot).

Since the early sixties Hill had began a second career as a mathematician, publishing the results of his research in mathematical journals and during the early seventies was an Honorary Research Fellow in the Mathematics Department at University College London [Fig 6]. By this time he had moved away from 'classical' quantitative maths to qualitative ideas like topology and graph theory as employed in works like "The Nine – Hommage a Khlebnikov" of 1976. At each stage in the development of his relief sculptures, aesthetic judgements were allowed to favour the direction taken. It was not simply that Hill chose the most attractive option resulting from a set of mathematical permutations, but that he adjusted the perceptual properties of the work with reference to mathematical ideas in order to achieve a bodily perception of their spatial structure. His works were not like the result of running a program – not even an interactive program that relies on being steered by choosing from pre-selected options. Nor were they like the visualisation of a program through its decomposition into a series of discrete graphic elements like an elaborate flow chart. They were more the result of a mathematical logic or 'thematic structure' being articulated or 'realised' by applying the varied refractions of different visual or sensory logics.

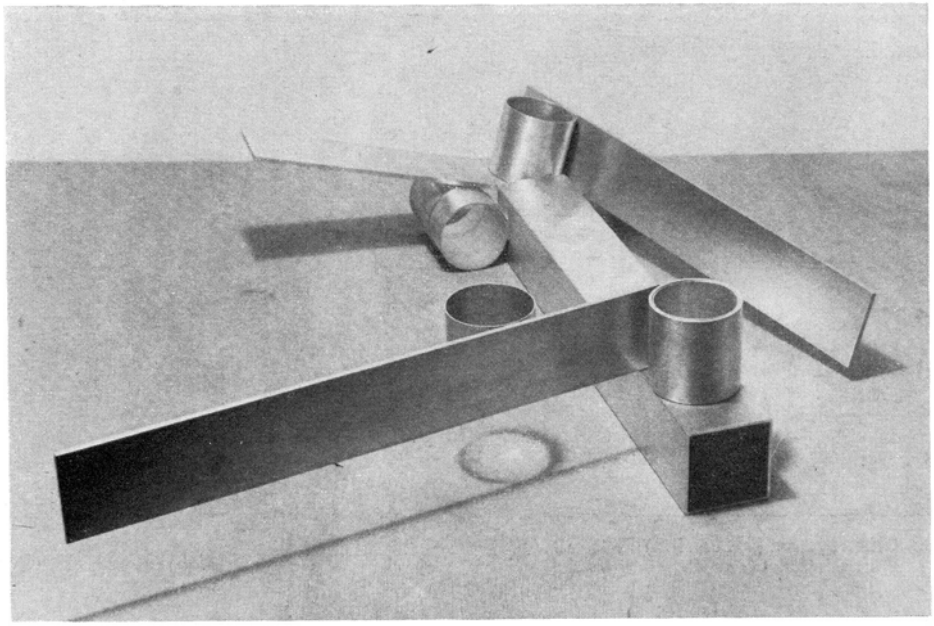


Fig. 7. Kenneth Martin, *Transformable (1st version)*, 1966.

At this point it is worth comparing Hill with the practices of his contemporary Kenneth Martin. Although each artist worked with an entirely different set of 'thematics', they both found ways to absorb systematic techniques into every pore of their creative thinking. Whereas Hill started with the

theoretical structures of maths, Martin started with movement. During the fifties Martin started to produce a series of “Screw Mobiles” and “Transformables” which were made by applying sequences of transformations to simple metal objects - typically bars, rings and rods [Fig 7]. The resulting sculptures exhibited the spatial displacements he applied by shifting and rotating them, twisting, expanding and contracting them in the form of a progressive series. Rings and bars might first be positioned in such a way that their relationship defined a set of possible actions or measured intervals. Sometimes the movements they defined could be described and replaced by the shape of a parabolic band. Sometimes the descent of a ring was replaced by a cylindrical extrusion or rod. The effect of forces like gravity to roll or oscillate objects when suspended was noted. These domains of movement were repeatedly exercised, transcribed, ordered by number sequences, transformed into shapes and then re-examined for the next stage of development.

Instead of concentrating on what kinds of rational structures could be used in the constructive process, Martin tried to structure the process itself by recasting each stage as one of a series of rhythmic changes. In this sense his approach was more general than that of Hill’s - “To be interested in the kinetic is to be consciously interested in sensation as such, for not only is form-making a corollary of movement, but so are sensation and feeling” [12]. It was as though he was trying to choreograph, as they happened, all the shifts and unfoldings that his mind, body and senses went through over the course of a creative enterprise. For Martin the kinetic experience was in the practice itself and he was therefore able to express movement without having to engineer actual movement, thus removing the necessity for any of Gabo’s hated ‘mechanical parts’. Although he described his analogue methods as ‘programmed’ transformations, it would be as difficult for us to appreciate today as if you tried to write a computer program by following the progress of leaves falling from a tree in a storm. They were programmed in the sense that “…a logic and a counter-logic are set in operation and the results are accepted” as his wife Mary Martin stated [13]. Furthermore, because his transformations were his own acts rather than machine executions, the experiential difference in making the work would be similar to that between climbing a mountain and taking the cable car [Fig. 8].

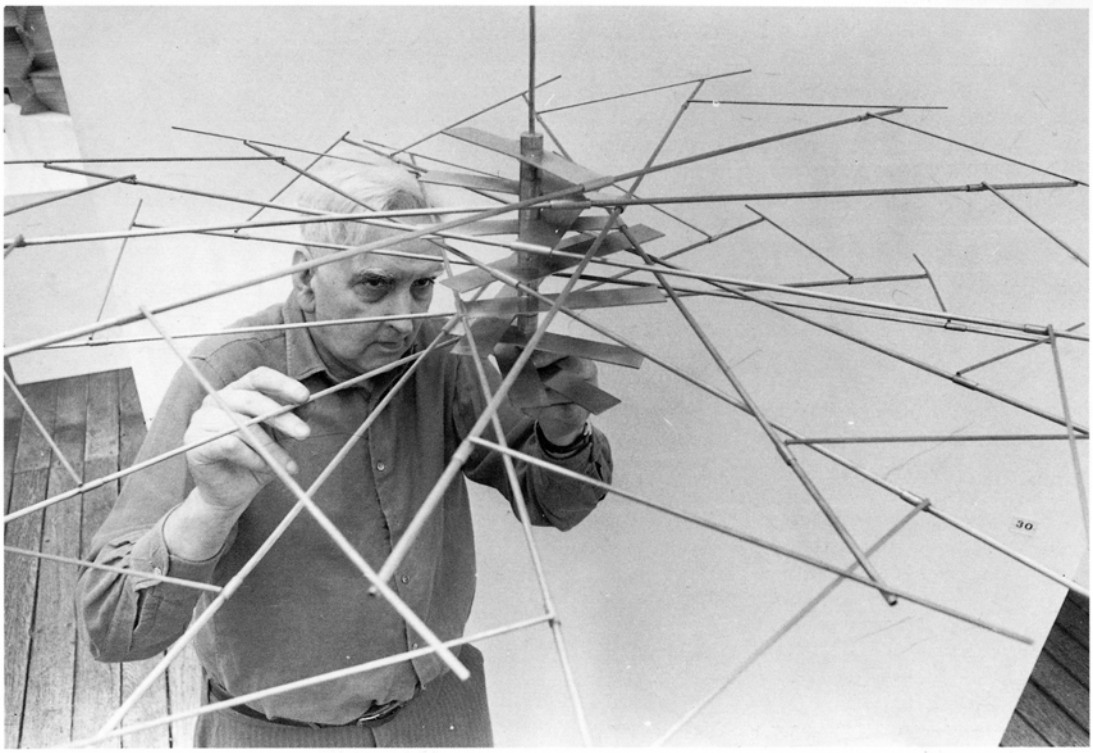


Fig. 8. Kenneth Martin with Screw Mobile, 1967. (photo: from *Kenneth Martin : the chance and order series, screw mobiles and related works 1953-1984.* Exhibition catalogue, Annely Juda Fine Art, 1999).

Systems from Another Planet

In 1969 the former Op Art painter Jeffrey Steele founded the Systems group, including John Ernest, Gillian Wise, Malcolm Hughes, Jean Spencer, Michael Kidner and several others. Many of the

previous generation of artists like Hill and Martin associated with it as it continued many of their aims, yet now with a more conscious emphasis on the constructive process itself as much as the resultant work. As they took advantage of the new techniques provided by post war mathematics and cybernetics the scale and complexity of the systems they were dealing with started to escalate and prompted new issues. The question of whether it was important that the 'underlying system' should be apparent in the final work, and in what sense the 'system' could realistically be called the content of the work began to be asked more and more. Artists like Hill and Martin had managed to avoid this issue by retaining a closeness between their different levels of systematic working. Another way to prevent the work splitting between a conceptual procedure and a perceptual result was to follow what Kenneth Martin had advised in 1964 that "…construction must start with the simplest and most practical means and to avoid confusion aim at the simplest results" [14]. But as the resources of formal logic became more and more sophisticated and prolific there was mounting pressure to move beyond the processing abilities that the human mind could keep up with.

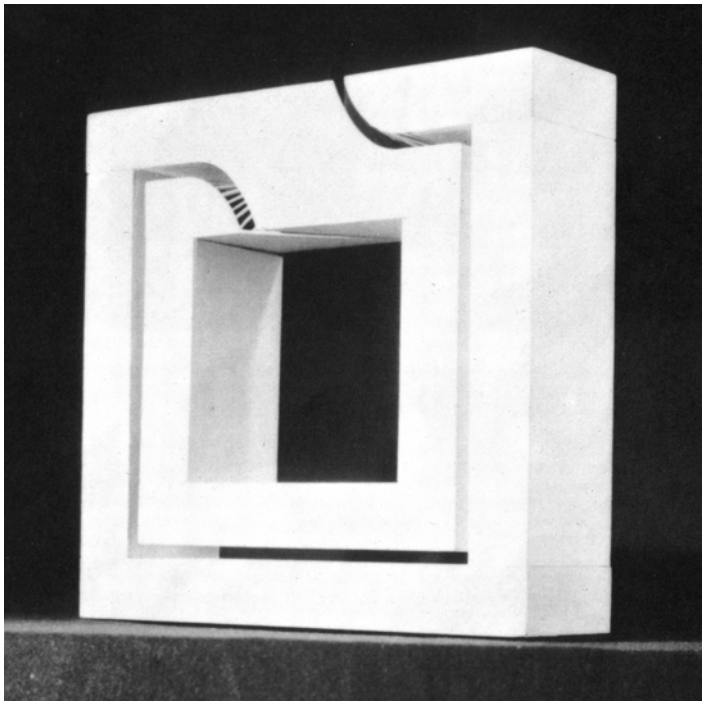


Fig. 9. John Ernest, *Moebius Strip*. Wood, metal, alkyd paint and adhesive: 2440 x 2140 x 585 mm, 1971-2.

As the different levels of materiality that could exist as a single 'system' began to multiply – knowledge, documentation, feeling, perception - it began to tax the Systems artists as to how they could tie together all these different bodies. For instance, artists like Gillian Wise and Malcolm Hughes thought it could be revealing to make visualisations of rational systems and use intuitive 'feeling' to help make new discoveries about them. Similar in technique to later applications of computer graphics in scientific visualisation, Hughes described "…a relatively unexplored intuitive creative area beyond the rational, where unexpected linkages are sensed and responded to by the mind via the senses" [15]. To test this idea, John Ernest made a series of sculptures based on modelling the mathematical Moebius strip [Fig. 9]. Hoping to make interesting discoveries about the relevance of its topological properties to the concrete world, he instead realised that the sculptures' properties as physical objects far outstripped their status as theoretical aids. Instead of the sculptures having a representational correspondence to a mathematical object, they were more accurately the result of the 'action' of a mathematical idea upon a physical material. The Systems artists realised that they were already beyond traditional modes of representational art or scientific modelling that relied on the consistent relation of ideas, objects and sensations.

The Systems group also made a more serious effort to compile their discoveries into a collective body of research. They often exhibited working drawings and notes alongside finished pieces to draw attention to "the course of the investigation". In 1978 Steele noticed that one could go on to collate and edit them into substantial documents that would have as much significance as the paintings. Other

artists such as Jean Spencer thought it should be possible to design a work in such a way that it completely documented itself, "…it is possible to display all permutations within a particular configuration of grids, and through the complete series reveal the nature of the system" [16]. It might even be possible for someone to recover the original system from an analysis of the work. But as the systems of construction strained to become more complex and abstruse, this looked increasingly impractical. For instance, the theorist Stephen Bann noted that the 'system' that one sees when one looks at these works might not be the one that created it but have a separate character formed by its visual qualities, "…the system of the work is not necessarily the systematic procedure that determined its creation, any more than the biographical details of the process of fabrication can be said to establish the way in which the work will affect the spectator emotionally" [17].

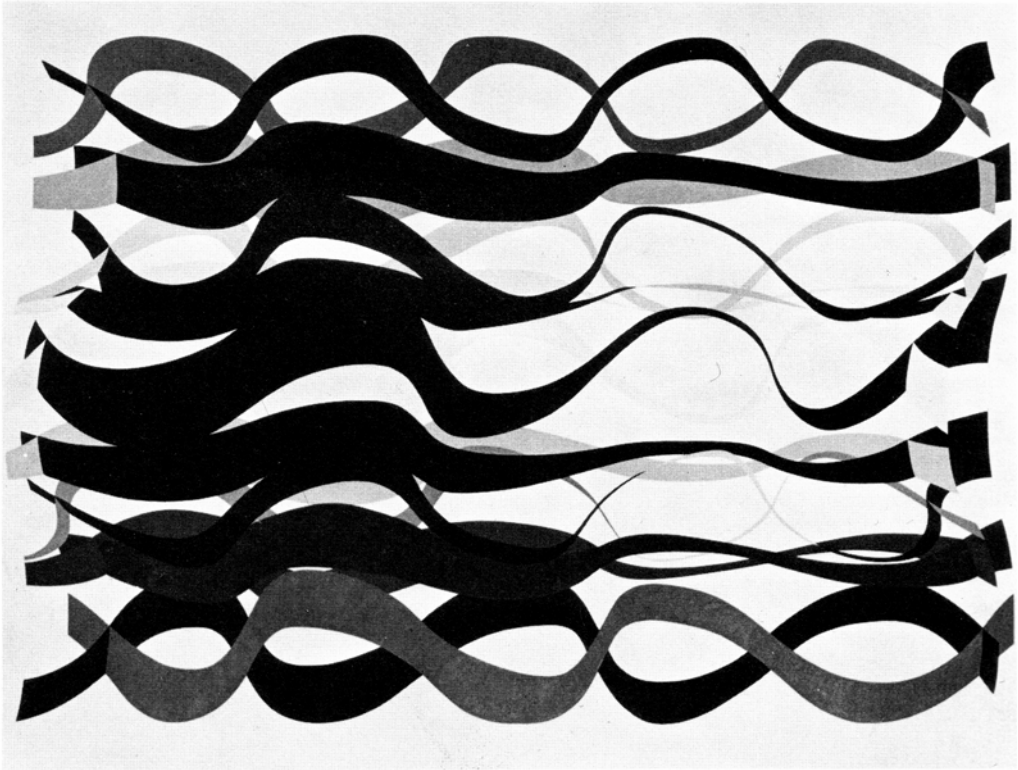


Fig. 10. Jeffrey Steele, *Medusa*. Oil on canvas, 914 x 1219 mm, 1969.

Some artists like Steele now pushed ahead in the direction of what we would now recognise as a fully materialist 'generative' art practice, including a renewed acceptance of the irrational [Fig. 10]. Constructivism had originally had a close relationship with Dada through figures like Theo Van Doesburg. Its attitude to chance as an objective phenomenon was summed up in works such as Hans Arp's famous collage of 1917 "According to the Laws of Chance", produced by tearing up pieces of paper and letting them flutter down onto his canvas like drops of rain [Fig. 11]. In 1972 Steele reformulated this interest to fit their programme of enquiry - "To grasp the full extent and power of systems entails giving as much attention to chance, deranged, anarchic systems as to those with a more manifest regard for law and order" [18]. Steele suggested that they should start building 'deranged' systems which would function in place of subjective motivations and personal significances. By examining the kinds of information that these systems could generate they might find a way to test or 'validate' them, not for their truth value or meaning but for their productive capacities, as engines of chaotically fertile invention. Systems could now be freed to move beyond human categories of order and disorder. To try to constrain them to the production of comfortable human meaning would be as pointless as "…trying to communicate by signals with an intelligence on another planet with whom we have no common experience and therefore nothing to communicate about" [19] [Fig 12].

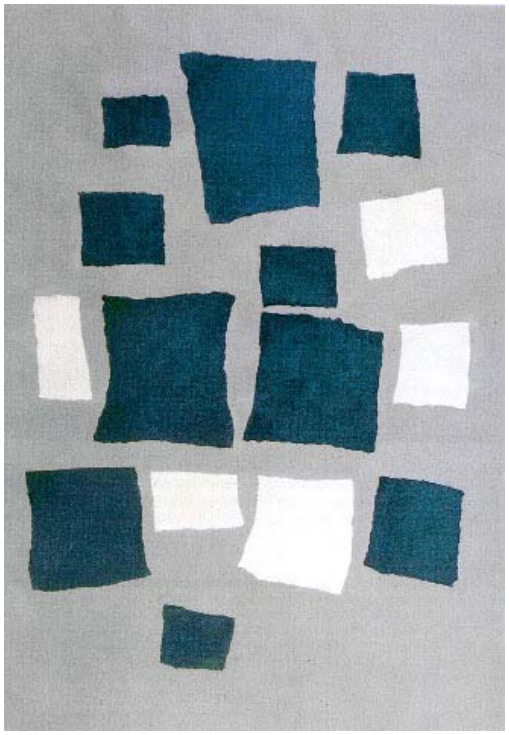


Fig. 11. Hans Arp, *According to the Laws of Chance.* Torn-and-pasted paper, 485 x 346 mm, 1916-17. (Museum of Modern Art, New York).

Fig. 12. Jeffrey Steele. (photo: from *Constructive Context* catalogue, 1978).

While some artists desired to stand back and give the system more room to grow, others worried that this would weaken the practice of retaining a close personal proximity between the artist and the system during the course of its unfolding. There arose a danger that the system would disconnect from the artist altogether, becoming a completely autonomous machine. An overview of the situation was provided by Kenneth Martin in 1968 when he divided systematic work into three types [20]. Firstly there was the completely predefined system which once set in motion could generate work independently of any further artistic input, what we would now usually refer to as generative art. Secondly there was a system that may be initially predefined but constantly altered through feedback, bringing into contact with other systems, etc – the 'program' is thereby written in conjunction with the work itself. Finally there is the system which builds up from a primary act without any previous planning, like a self propelled aggregation of logical steps – the writing of the program is indistinguishable from the practice itself. Martin himself thought that the second category would hold the most for the artist because - "The act of programming will be in operation throughout the whole progress of the work" [Fig 13]. For artists like Colin Jones, a continuous relation between the artist and his system was also paramount for a process of discovery to take place – the system being modified during the course of the construction of the work would therefore allow a "continual meditation [by the artist] on the possibilities of connections" [21]. For Martin, the more the system is predetermined like the first example, the more problematic things become, not just because of the marginalisation of the artist but because of the systems distance from the specificity of any given situation – "…it is difficult to predetermine a system for forms whose properties one is in the way of discovering". It is more a question of how one can be expected to work with a form of logic without the direct motivation and stimulus of the object of that logic – such as its material consequences or its physical or historical situation. One is inventing a process, not just a program. It is this awareness of trying to retain a purchase on formal systems as the computer made them more and more autonomous that would become an increasingly pressing concern.

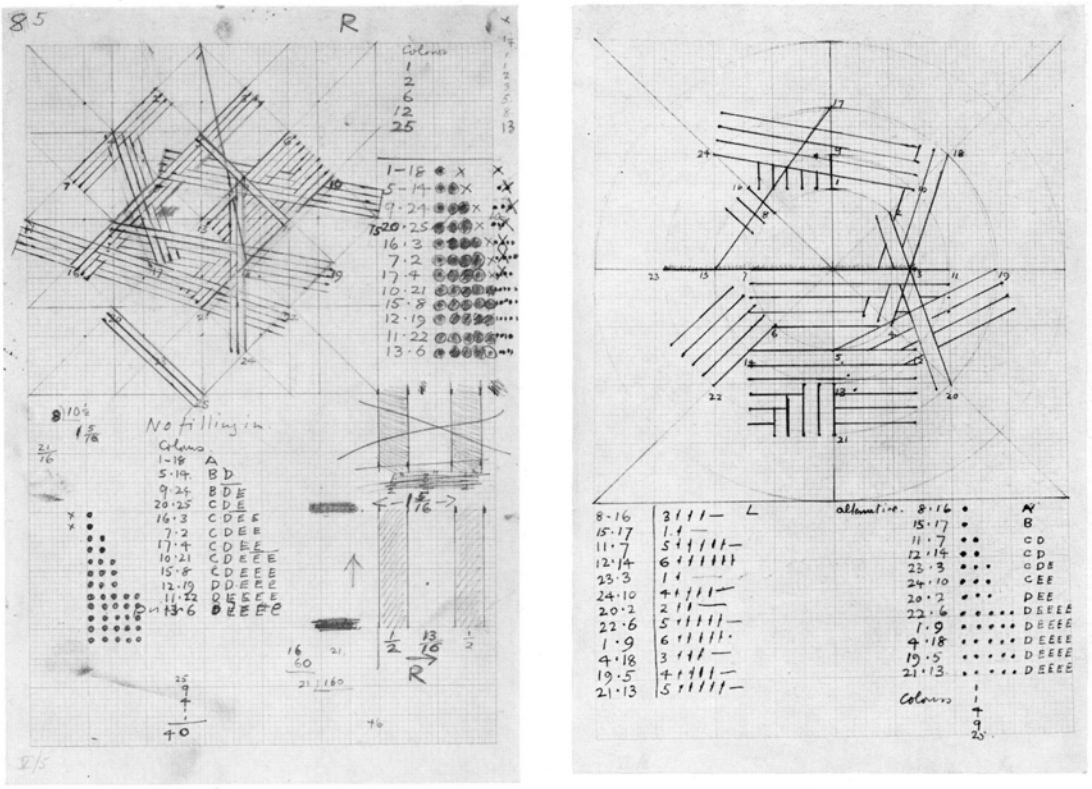


Fig. 13. Kenneth Martin, *Drawing for painting Chance and Order 8 (five colours).* 1971.

Program, Be Programmed or Fade Away

The neo-constructivists of the post war period had often referred to their methods as a form of ‘programming’. Yet despite the mounting complexity of their ‘programs’ and the opportunities for practical implementation afforded by computer programming, most Systems artists continued with rulers and graph paper. Later Systems artists like Tony Longson became keen programmers and Malcolm Hughes went on to found the Experimental and Electronic Art Department at the Slade School of Art, becoming a hub of activity for a new generation of ‘Computer Artists’ in the late seventies. But there are several reasons why the reticence of the others might have made sense, quite apart from the fact that several confessed to finding the discipline of programming beyond their abilities.

To begin with, formal programming languages made it difficult to mix together very different kinds of logic. Everything had to be reduced and encoded into the same terms. The programmer had to formulate their task in terms of an algorithm, type in a large body of text that imposed some very unforgiving rules of syntax and then painstakingly debug the whole thing. Constructivists were by this time used to switching freely between different number systems, geometries, topologies and all sorts of methods on the informal basis of what was suggested to them by exercising their shiny Perspex tiles and exploring the plastic possibilities of the picture plane. To have to find a way to translate an act as fundamental as a shift in ones mental focus into Cartesian coordinates and conditional statements sounded pedestrian. Programming offered them little more than the ability to calculate various permutations and combinations of elements that were relevant to only a part of their overall practice.

The Constructivists were used to identifying their systems with the concrete actions, matter and sensations that had inspired them. Jean Spencer had stated that “…a system cannot be taken out of the context it originated in” [22]. The making of a constructed relief was derived from structuring processes like moulding, resistance, mass, occlusion and the acting of rational operations upon them. Even if these physical qualities could be simulated through operating computer software, its functioning would not be linked directly to the manipulation of the source materials but would be a limited abstraction of their assumed potentialities. It was not that the Constructivists reliance on tangible processes gave them systems that were superior or more useful than those of formal logic. But

the inclusion of physical and analogue systems gave them a richer perspective on the whole formative process. Computer programming might have universal potentialities in theory but this very freedom could become problematic. When objects are digitally defined one must approach their potentialities from some point of interest in order to avoid becoming lost in them, as Kenneth Martin had hinted. When one is modelling the properties of physical metal rods and rings in a computer simulation one can model any properties in any way one likes but a decision must be made. And once that decision is made then the rods and rings themselves tend to be lost as sources of unknown procedural insight. What then, the Constructivists might have asked, can take their place?

Fig. 14. Norman White, *Facing Out, Laying Low.* Plexiglas, motors, custom electronics, 1977.

Some artists did try to use techniques such as interactive sculpture to make computer programming part of a wider system of human behaviour and cognition with some success such as Edward Ihnatowicz's famous "Senster" sculpture of 1970. The more complicated these constructions necessarily became with all their logical, electronic and mechanical components, the more they began to suffer from Gabo's 'black box' problem of sculptural clumsiness and functional inscrutability. Norman White's 1977 piece "Facing Out, Laying Low" used photo electric cells to detect light patterns and emit tones [Fig. 14]. Describing himself as "an artist of logic", White hoped that it would be simple enough for visitors to be able to work out its principles by performing little experiments on it and testing its responses [23]. He also encased all the electronic circuitry in transparent Perspex to encourage their enquiry into its functioning. The programs that controlled these sculptures still remained invisible yet they were clearly not representational pieces that communicated an underlying coded 'idea'. But they could not offer the audience a completely 'open' construction either and instead moved towards explicating themselves as effects.

It should have been possible to put software into the mix of a wider practice of systematic art. Yet computer programming is a jealous mistress. From the beginning of the eighties the pressure was on to standardise all aspects of computing ready for mass consumption and moving all possible functions into software was a cheap and flexible way of achieving that. Software would now automate all possible operations - instead of seeing manual dexterity and gesture as a way to structure process, it was reduced to the input of parameters or a direct mapping onto pixel values as in 'electronic painting'

[24]. These tendencies were reinforced by the development of interface models and stabilised by the menu lists, parameters sliders and icons of the modern windowing environment. The computing environment was becoming more and more orientated towards electronic forms of display, individual workstations and the standard computer lab provided by university learning resources. By the middle of the eighties computer based art would largely be produced on desktop boxes and consumed through desktop boxes. Under these conditions it was hard for many artists to find much enthusiasm for a visual space that was increasingly colonised by unsympathetic interests.

Through the increasing dominance of structured programming styles, the computer began to absorb all systematic means of expression – encoding them into macros, object classes, libraries, data types and file formats, categorising and separating them out into myriad sets of structural elements. The granularisation of the creative process into logical decision making impeded its natural flow. The more intimate one gets with coding the more narrow ones practice threatens to become due to the kind of expertise required – having to relate to each proprietary component of a system through its technical specification rather than its technical potential. The Systems artists couldn't use the intimate physical and perceptual qualities they were used to as a basis for their investigations in programming languages and this lack of bearings threatened to turn the unfettered formal power of computer logic into a blizzard of arbitrarily designed information ordered only by contingent commercial agendas. Some of these issues had been foreseen by the neo-constructivists as early as the sixties as they attempted to structure each nuance of their working process with greater and greater exactitude. The Systems artist Gillian Wise had written "working with a concrete form with discipline…leaves one more conscious of the irrational or non-rational element in taking decisions, and, in making very precise choices, the range of possibilities often seems overwhelming" [25].

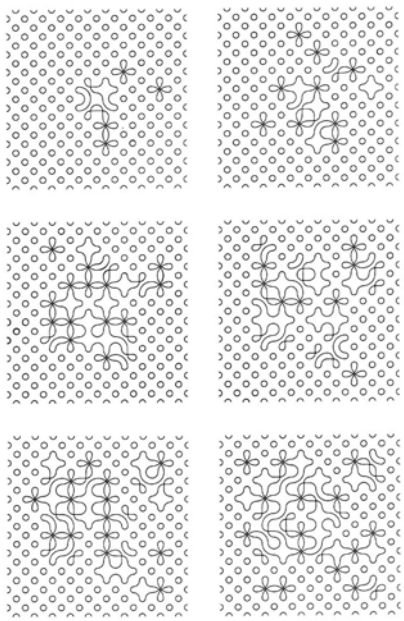


Fig. 15. Paul Brown, *Lifemods Series1*. 8 computer assisted drawings, ink on card, 1978-79.

Yet some artists were willing to throw themselves into the maelstrom and take on the strictures of the code. In 1978 the Computer Artists based at Malcolm Hughes Experimental and Electronic Art Department published a catalogue of their recent graphics and sound work with the help of Jean Spencer. "Working Information" featured pieces including Chris Briscoe's generative audio, Darryl Viner's animations and plotted graphics by Peter Beyls [26]. The following year there was a student show "EXP at P.C.L." featuring Paul Brown's computer simulations, Steve Bell's interactive graphics and perceptual studies by Dominic Boreham [27]. Visually the work was formally more sophisticated and texturally richer than previous Systems work, but most striking was the sheer quantity of graphics and audio that was now being produced, something approaching a continuous torrent of sensory data [Fig. 15].

This was the most obvious change in programmatic art as it entered the decade of the eighties - it came to be about images. Jagged lines were anti-aliased, planes were shaded, spline curves were smoothed

out. The increasing continuity of the visual surface now possible in computer graphics made it very difficult for it to retain an explicable connection to the program that generated it. But in between this loss of representational function and the move towards visualisation there lies a certain form of numerical image which asks to be accounted for. This is the kind of image that flourished in SIGGRAPH Art Shows, IMAGINA conferences and glossy coffee table books like 'The Beauty of Fractals' [28]. In order to construct it data was 'grabbed' or 'captured', plotted, extrapolated, extruded and massaged by dozens of algorithms, then ray traced, smooth shaded and cibachrome printed out. This image was like the result of collections of different systematic components yet without an actual system itself – being guided instead by executive opportunism, scientific curiosity, engineering prowess and artistic confusion. For some viewers the reaction was to impute to it a symbolic content, becoming a sign for technology without telling us anything about it. For others it seemed to float free from liabilities and significations entirely, its strident visual qualities standing alone for its raison d'etre. It is this difficulty in connecting which made the numerical image another factor in the alienation of the artist programmer.

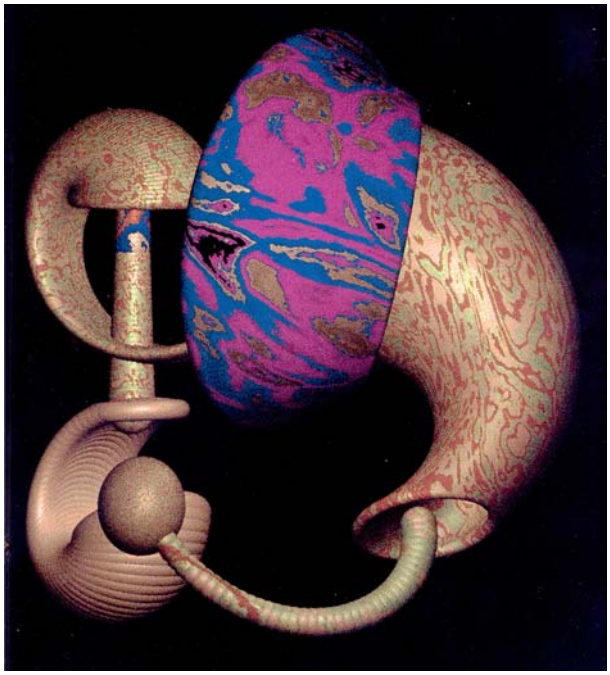


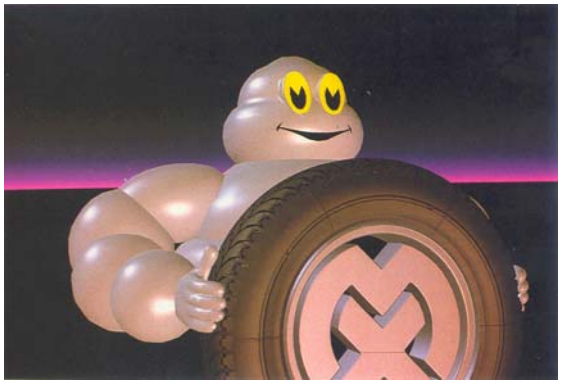
Fig. 16. William Latham, still from *The Conquest of Form* series. Digital image and video, 6 mins, 1988-90.

By the early eighties, the previous paradigms of cybernetics and ecology were outstripped by the more inward issues of modelling, representation and meaning. As if in rehearsal for the conversion of the bureaucratic society into the information society that would occur over the next twenty years, Computer Artists turned from the original resolution of the post-war English Constructivists not to abstract from the world to a perverse version of Biederman's realism. For this time they were not abstracting from the "structural process" level of nature but were implementing and mixing different models of nature, and not so much with the aim of gaining knowledge of nature but as a way of giving a direction to the formal freedom the computer had unleashed. Scientific models were hacked until they contributed only the required operational components, a montage of physical laws, mathematical calibrations and logical grammars. Biederman's realism had returned as a formalism. By mimicking a set of realistic styles and conventions, computer art could create a familiar reference for its arbitrary generative power [Fig. 16]. It was now a matter of systems modelling other systems and becoming increasingly rarefied [29].

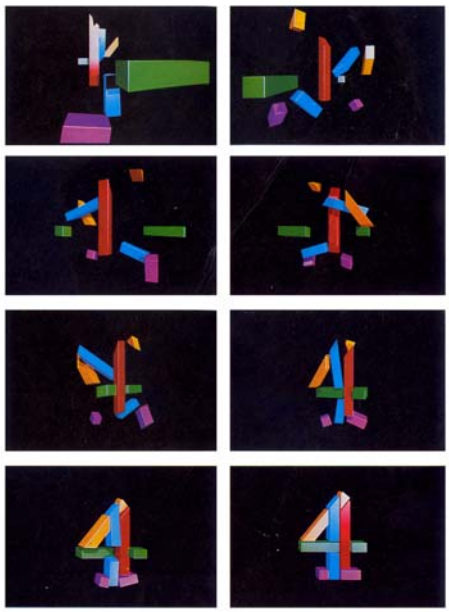
The work of Harold Cohen is a good example of this search for a new basis for the constructive process under the absolutism of code. In the mid seventies Cohen decided to give up his career as a successful painter and turn to programming full time. His aim was to reproduce his practice as a painter using artificial intelligence techniques. He wrote a program called AARON which was able to control a small device to paint simple marks, fill in shapes, sketch textures. Cohen sought to recreate himself as an "expert system", using a model of art making as a process of cognitive development. He built up a

series of programming functions that could construct a plausible painted image from scratch. Yet in the end the project failed in its original objective - it was not possible to tell from the image what was the cognitive function any particular element [30]. The program was in fact more the simulation of mark making, a 'Turing Test' for painting. This was the new performative mode of knowledge, a behavioural technique that produces the required results but without any necessary explanatory value. Cohen had succeeded in substituting the inexplicable psychic volitions of the artist for the empty performance of the simulation. Instead of remaining so resolutely human centric in his focus, Cohen could have taken advantage of this discovery and recast 'human' drawing as a subset of 'machine' drawing (a tactic that Jeffrey Steele might have approved of). Machine logic undermines subjectivity, knowledge and authenticity by copying them, but without offering an alternative to those categories the power to copy and to manipulate that copy then becomes equally as dominant. Without finding this wider context, if Cohen's work had at first functioned as an effective critique of artistic subjectivity, by the eighties it paradoxically reinforced the new anthropomorphic and metaphorical approach of the desktop interface design as the default strategy.

The Systems artists were well aware of the tradition in Constructivism of applying their aesthetic inventions outside of the domain of art, most commonly to that of architecture. But with the possibilities of using the computer's instrumentality closed to them, their insights were leading them into a practice that was both more ambitious and more introverted. When considering the lack of a suitable route for the social diffusion of their ideas, Jeffrey Steele lamented in 1978 that "this particular function remains symbolic and the present social use of this art is mainly critical and didactic" [31]. This painted them into a difficult corner, for Constructivist artists were also ideologically 'constructive' - progressive and utopian, they believed that it was the destiny of artists to make a contribution to advance society's well being. In contrast, the rising force of Conceptual 'systems' artists like Sol Le Witt and Adrian Piper were more openly critical and oppositional, self-reflexive and increasingly ironic. English Constructivists like Roy Ascott and Stephen Willats that were closer to this conceptual approach survived better, able to adapt their practice to a wider range of technological and discursive contexts. So too did the Computer Artists, who, instead of architecture, eventually found a practical outlet that could support their hunger for complexity and scale in the form of television and the "creative industries" [Fig. 17]. But for the Systems Constructivists, there was nowhere left for them to go. Unlike the Conceptualists, they were still resolutely visual artists yet unlike the Computer Artists their intimacy with and erudition concerning 'the system' was usually too great to allow a recalcitrant machine to come between them.



Figs 17. Lodge-Cheeseman Ltd, *Michelin Man* advert. Computer animation by Digital Pictures Ltd (Chris Briscoe and Paul Brown), UK, 1983.



Channel 4 (UK) station ident. Designed by Robinson Lambie-Nairn agency, computer animation by System Simulation and Information International Inc, 1982.

The System of Software

It was the internet that finally recreated the computer as a mass medium and brought with it a new technology, a new audience and a new system – the network. Now that the conduits of society had been replaced and restructured using the fibre optics and ADSL of information technology, programming could more fully become the subject of a systematic art as well as its technology. Everyone now has to use software to work, to communicate, to spend their leisure time. By the end of the nineties this shift was finally recognised in the emergence of "Software Art" – that the formation of subjectivity and social relations were now within the domain of software encoded exchanges [32]. For this reason Software Art has seen itself within the tradition of Media Art or Conceptual Art rather than the progeny of Constructivism. Computer Art has acted as the engine of their historical transition yet without passing on its aesthetic agenda.

But this mass integration of computing has also brought mass normalisation – the homogeneity in patterns of usage, streamlined design templates, reductive interface models, restrictions in access to information. Whereas during the last years of the twentieth century these forces were the subject of conflict and critique, within a few short years they had settled into universally accepted strictures of browser navigation, digital rights management, search engines and the standardisation of Object Orientated functionality [33]. To oppose these edifices much faith has been put in practices like Free and Open Source Software (FLOSS), yet without a creative agenda its main achievement to date has been the LINUX development platform for an audience conditioned to expect free imitations of Microsoft applications. In the art world the dominant aesthetic of conceptualism is also ill equipped to deal with the demands of software culture. The success of software and Software Art is dependent on the material contingencies of its deployment and perception, not on an appreciation of the "idea" behind it. Its extreme sensitivity to "look and feel" and other unforeseen consequences of actually using it makes it impossible to decide what is or is not essential to the purposes of the "concept". We have now gotten to the point where critics evaluate software based art by reading publicity mailouts, without looking at or engaging with it directly, despite the fact that as software it is uniquely able to be tested in a wide variety of situations. Like conceptualism in art, government sponsored agencies and corporations use code to construct social reality in isolation from the full implications of that reality. And the means by which that code is itself constructed through the discipline of software engineering is also guided by standards designed to achieve industrial and commercial efficiency.

Systems were about process, computer programming was about control. Software is about fitting in, observing standards, listening to the message queue, relinquishing control over context. Under these conditions, where does the artist's 'system' end and the computer begin? The proliferation of materialities – codes, interfaces, platforms and output devices creates confusion about where the focus of our attention should lie and how to keep the construction 'open' under such conditions. "While every art form may be processed and mediated in one way or another, it usually does not constitute a fusion of fundamentally different 'materialities'…as software art does" (Christiane Paul) [34]. Yet fused they are, and it is in the tracing of the passages and leaks between these levels that the art of the system now lies.

Conclusions

Systems artists were the last programmers before the digital computer made that practice synonymous with its own functioning. Through their intimate proximity to the many varieties of order it was as though they trained themselves to act creatively like a species of computer, internalising procedural patterns and abstract logic and running them on their own wetware. They absorbed the programmatic into the very core of their thought processes until the logic of series, modularity and permutation became an indistinguishable part of their perceptions and sensibilities. But for an audience, the work could be as inscrutable as the most introspective of subjective art, as though each work a private programming language, emphatic yet utterly remote, produced by 'an intelligence on another planet'. At times they seemed half paralysed by the struggle to wrest every decision from the guardianship of order without resorting to the blindness of subjective intention. It became a hermetic practice - a faint reminder of a kind of deliberate psychic objectification that has not been seen for hundreds of years, perhaps since the alchemists of the pre Enlightenment era identified their own subjective inflections with the drama of chemical experiments. This why Anthony Hill once described himself as a Solipsist. Like an adept, it required a mental attunement to a discipline of thinking that largely benefited a process of personal development for the artist themselves.

Without the ability to share and disseminate their techniques more widely and without an external context for their work that was familiar to their audience, Systems artists diversification of the 'programmatic' turned in on itself. It might have helped to return to the Constructivist tradition of looking outwards and seeking a concrete effect in the external world. It is just this practical process of testing, deployment and dissemination that is now easier for software based art due to its integration into the technocratic infrastructure.

Constructivists did retain a belief in the power of aesthetic and sensory perception to make a significant contribution to knowledge beyond the theoretical or cognitive. 'Precise feeling' can tackle problems that reason cannot formulate [35]. And Systems artists in particular integrated formal language into creative thought to the degree at which an artist can reclaim the rational as part of a more heterogeneous intuitive practice. There is now a fresh desire amongst artists to open up the wider expressive potential of formal logic and abstract machines beyond the atrophied state of software, to make code directly perceptible, embodied, 'affective'. Can a 'systematic means of expression' bring the operations of modern software within the human distance that the Systems artists enjoyed yet retain a relevance to the complexities of the networked society? Can we use the wider range of expressive means that are now available in digital media to get this kind of practice out of the artists' heads? It is at this current point in history that the problem of how discoursive categories arise from computation, of how 'conceptual structures' and 'mathematical themes' might be realised in a form that has a relevance for the uninitiated might become more tractable.

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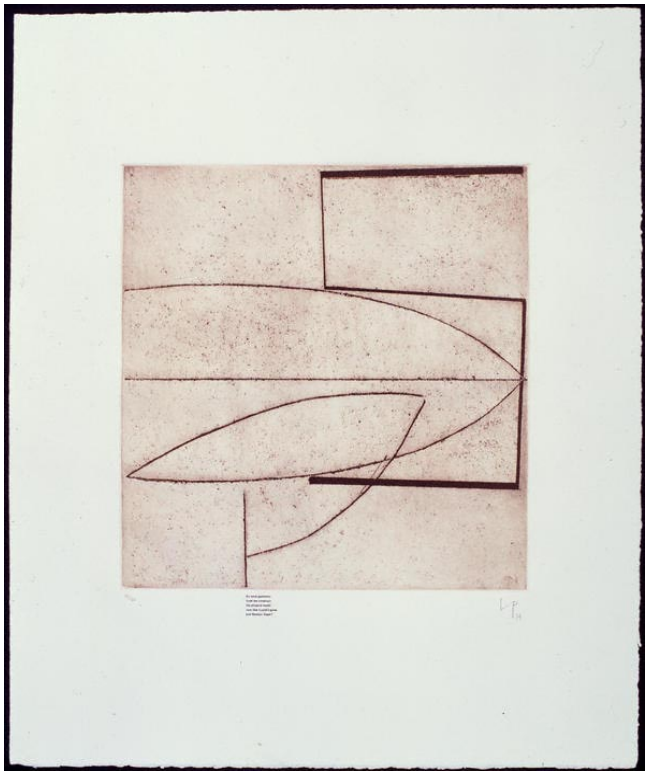

Fig. 18. Victor Pasmore, *By What Geometry Must We Construct the Physical World?* (from *Word and Image).* Intaglio print on paper, 400 x 392 mm, 1974 (Tate Gallery, London).

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Illustrations

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2. Naum Gabo, *Kinetic Sculpture (Standing Wave).* Metal, painted wood and electrical mechanism, 616 x 241 x 190 mm, 1919-20.
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14. Norman White, *Facing Out, Laying Low.* Plexiglas, motors, custom electronics, 1977. (Artist)
15. Paul Brown, *Lifemods Series1*. 8 computer assisted drawings, ink on card, 1978-79. (Artist)
16. William Latham, still from *The Conquest of Form* series. Digital image and video, 6 mins, 1988-90. (Artist)
17. Lodge-Cheeseman Ltd, *Michelin Man advert.* Computer animation by Digital Pictures Ltd (Chris Briscoe and Paul Brown), UK, 1983.
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