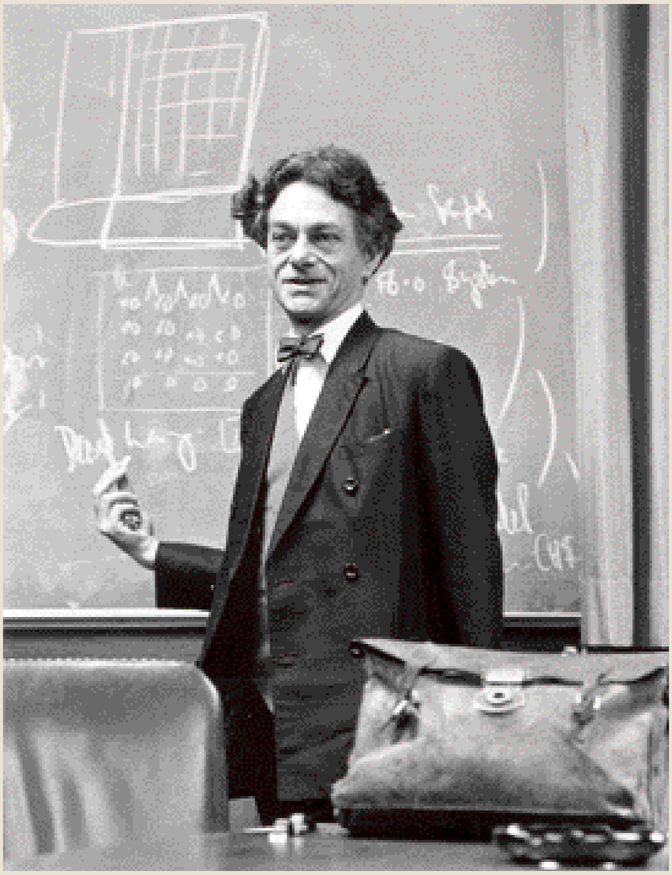
The Architectural Relevance of Gordon Pask

Usman Haque reviews the contribution of Gordon Pask, the resident cybernetician on Cedric Price's Fun Palace. He describes why in the 21st century the work of this early proponent and practitioner of cybernetics has continued to grow in pertinence for architects and designers interested in interactivity.

It seems to me that the notion of machine that was current in the course of the Industrial Revolution – and which we might have inherited – is a notion, essentially, of a machine without goal, it had no goal 'of', it had a goal 'for'. And this gradually developed into the notion of machines with goals 'of', like thermostats, which I might begin to object to because they might compete with me. Now we've got the notion of a machine with an underspecified goal, the system that evolves. This is a new notion, nothing like the notion of machines that was current in the Industrial Revolution, absolutely nothing like it. It is, if you like, a much more biological notion, maybe I'm wrong to call such a thing a machine; I gave that label to it because I like to realise things as artifacts, but you might not call the system a machine, you might call it something else.

Gordon Pask[1]



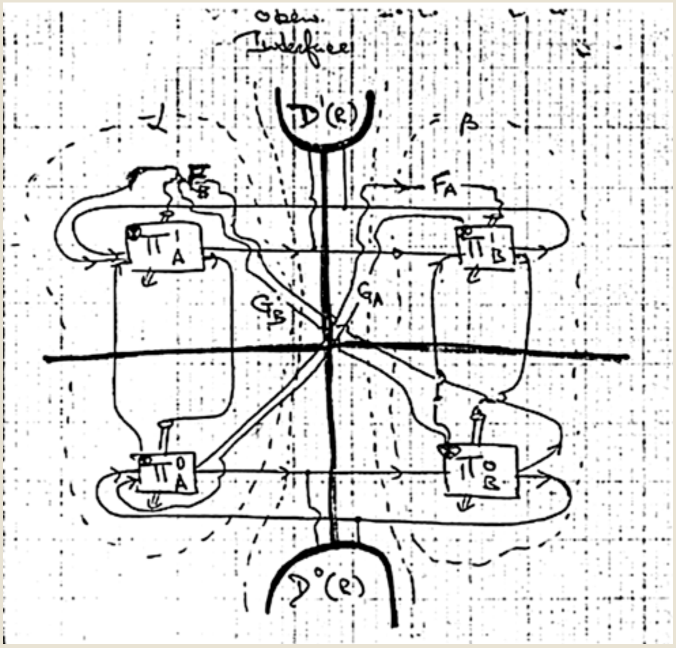
Gordon Pask, cybernetician.

Gordon Pask (1928–96), English scientist, designer, researcher, academic, playwright, was one of the early proponents and practitioners of cybernetics, the study of control and communication in goal-driven systems of animals and machines. Originally trained as a mining engineer, he went on to complete his doctorate in psychology. His particular contribution was a formulation of second-order cybernetics as a framework that accounts for observers, conversations and participants in cybernetic systems.

Pask was one of the exhibitors at the 'Cybernetic Serendipity' show staged at the ICA, London, in 1968, curated by Jasia Reichardt, an exhibition that became the inspiration for many future interaction designers. The interaction loops of cybernetic systems, such as Pask's Colloquy of Mobiles (1968), where actions lead to impacts on the environment that lead to sensing and further modification of actions, are core to the notion of a Paskian environment. He is also known for his Conversation Theory, a particularly coherent and potentially the most productive theory of interaction encompassing human-to-human, human-to-machine and machine-to-machine configurations in a common framework.

There has recently been a ground swell of interest in Pask's work by architects, artists and designers,[2] though his association with architects stretched back to the 1960s, through to the early 1990s, with collaborations undertaken in particular at the Architecture Association, London, and with the Architecture Machine Group at MIT (later to become the Media Lab). It may be argued that these collaborations were too far ahead of their time and were not fully grasped by the wider architectural community, but they did help to set the foundations for dynamic, responsive and authentically interactive environments.

The extent of Pask's research, theories and artefact design/construction was enormous.[3] As such, different groups of people find completely different tracts from his back catalogue relevant to their own work. In the 1960s, he worked with the architect Cedric Price on his Fun Palace project as



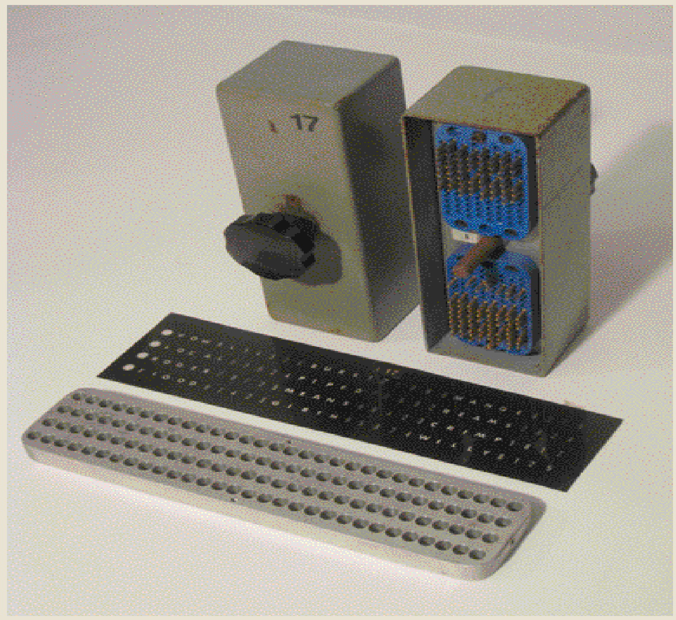
'Architecture of Conversations', sketch by Gordon Pask to annotate a conversation between two individuals (designer and co-designer) giving rise to an environment; an external observer can attribute intelligence to this environment.

Now, at the beginning of the 21st century, Pask's Conversation Theory seems particularly important because it suggests how, in the growing field of ubiquitous computing, humans, devices and their shared environments might coexist in a mutually constructive relationship.

resident cybernetician, introducing the concept of underspecified goals to architecture systems. In the 1970s, Pask's contribution to the philosophy of MIT's Architecture Machine Group was focused around the notion of architecture as an enabler of collaboration.[4] And in the 1980s and early 1990s, architects such as John Frazer at the Architecture Association were particularly interested in how Pask's adaptive systems might be applied to the architectural design process in order to evolve building forms and behaviours.

Now, at the beginning of the 21st century, Pask's Conversation Theory seems particularly important because it suggests how, in the growing field of ubiquitous computing, humans, devices and their shared environments might coexist in a mutually constructive relationship. If we think of having conversations with our environments in which we each have to learn from each other, then Pask's early experiments with mechanical and electrochemical systems provide a conceptual framework for building interactive artefacts that deal with the natural dynamic complexity that environments must have without becoming prescriptive, restrictive and autocratic.

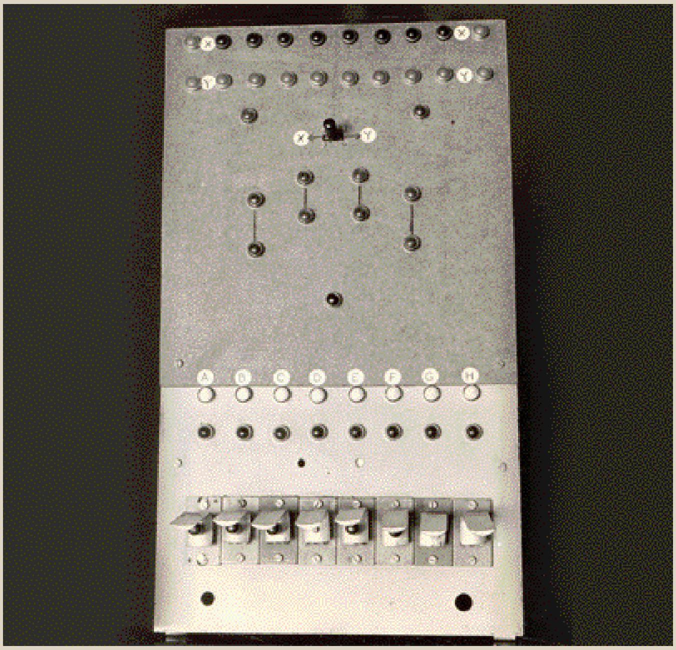
In this context, his teaching and conversational machines demonstrate authentically interactive systems that develop unique interaction profiles with each human participant. This approach contrasts sharply with the 'Star Trek Holodek' approach often attempted in so-called intelligent



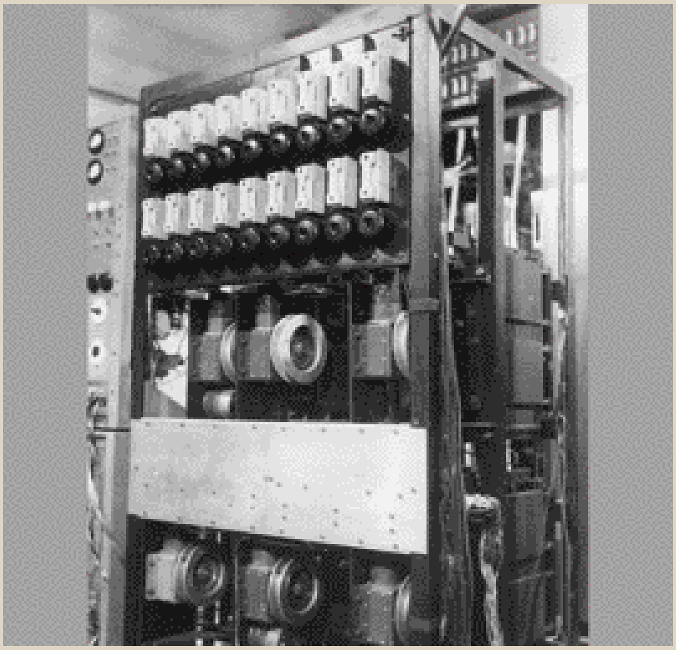
A photo of what is believed to be the last remaining fragment of a SAKI machine. The queries and correct responses are defined by metal 'bits' placed in an array, much like punch cards were used in early computers.

environments, which presumes that we all see all things in the same way and which denies the creative-productive role of the participant in interactions with such environments. Pask recognised, for example, that interpretation and context are necessary elements in language – as opposed to locating meaning itself in language – which is particularly important to consider for any design process, not least the construction of architectural experience.

His theories on underspecified and observer-constructed goals have been a major influence on my own work. In 1996, tutored by Ranulph Glanville, former student and collaborator of Pask, and Stephen Gage, also a Pask aficionado, my final architecture school project, Moody Mushroom Floor, was an interactive floor system of sound, smell and light that determined its outputs in relation to fluctuating goals and perceived responses – no behaviour was preprogrammed.



An early Paskian machine.



Gordon Pask and Robin McKinnon-Wood, MusiColour, 1953
The performance system was installed at several locations around the UK. This image shows the control system as installed at Mecca Locarno in Streatham. MusiColour appeared for a final time in 1957.

More recently, Open Burble (2006) was an attempt to build a constructional interactive system, in the sense that the participants both affected the structure, by moving it throughout a park, and constructed the way the structure responded to them by designing and assembling the modular structure themselves as they chose. Finally, the ongoing projects Paskian Environments (with Paul Pangaro, another former student and collaborator of Pask) and Evolving Sonic Environment (with Robert Davis, Goldsmiths' College) aim to provide concrete and pragmatic strategies for implementing Pask's theories in an architectural context.

What follows is an understanding of how Pask's lifetime work can be made even more relevant than ever to the practice of architecture. Pask certainly thought and wrote a lot about the field, but some of the concepts described here are founded on my interpretation of his projects, which even he may not have considered architectural. In places I simply try to extend to the field of architecture the approaches he invented; in others I use concepts that he constructed to consider alternatives to our current assumptions about architecture.

Four of Pask's projects in particular give hints about how to create richer, more engaging and stimulating interactive environments. It is worth bearing in mind that each of these predates the common digital computer and was therefore constructed mainly using analogue components. The descriptions below have been simplified, which is somewhat counter to the spirit of a Paskian approach – often necessarily complex – but it is hoped they will provoke the reader to follow up with Pask's own writings, which cover both the theories and the results of the projects he actually constructed.[5]

The MusiColour Machine,[6] constructed in 1953, was a performance system of coloured lights that illuminated in concert with audio input from a human performer (who might be using a traditional musical instrument). MusiColour should not be confused with today's multicoloured disco lights that respond directly to volume and frequency in a preprogrammed/deterministic manner. Rather, with its two inputs (frequency and rhythm) MusiColour manipulates its coloured light outputs in such a way that it becomes another performer in a performance, creating a unique (though non-random) output with every iteration.

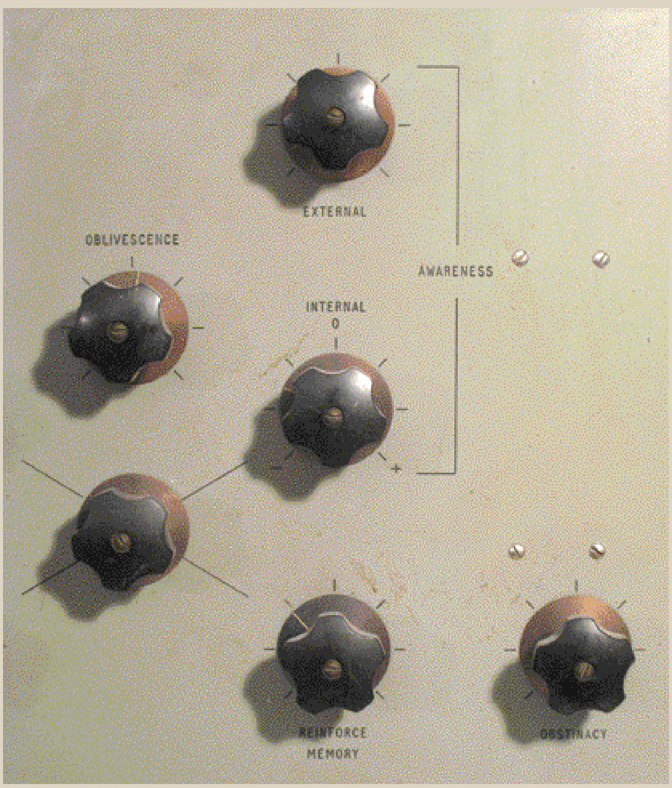
The sequence of light outputs might depend at any one moment on the frequencies and rhythms that it can hear, but if the input becomes too continuous – for instance, the rhythm is too static or the frequency range too consistent – MusiColour will become bored and start to listen for other frequency ranges or rhythms, lighting only when it encounters those. This is not a direct translation: it listens for certain frequencies, responds and then gets bored and listens elsewhere, produces as well as stimulates improvisation, and reassembles its language much like a jazz musician might in conversation with other band members. Musicians who worked with it in the 1950s treated it very much like another on-stage participant.

The innovation in this project is that data (the light-output pattern) is provoked and produced by the participants (other musicians) and nothing exists until one of them enters into a conversation with the designed artefact. In this participant-focused constructional approach, the data evoked has no limits.

Pask constructed a system that aspires to provide enough variety to keep a person interested and engaged without becoming so random that its output appears nonsensical. How these criteria (novelty vs boredom) are measured is core to the system.[7] This calculation is constantly being reformulated on the basis of how the person responds to the response. Unlike the efficiency-oriented pattern-optimisation approach taken by many responsive environmental systems, an architecture built on Pask's system would continually encourage novelty and provoke conversational relationships with human participants.

The Self-Adaptive Keyboard Instructor (SAKI), designed by Pask and Robin McKinnon-Wood in 1956, was essentially a system for teaching people how to increase speed and accuracy in typing alphabetic and numeric symbols using a 12-key keyboard.[8]

Whereas contemporaneous teaching machines followed a learn-by-rote model, in which a student attempts to emulate and is then scored for successes, SAKI mimics the possible relationship between a human teacher and student. A teacher is able to respond directly to a student's apparent needs by focusing at times on particular aspects of the material to be studied if weaknesses are measured in these areas. This is achieved in Pask's constructed system via the dynamic modulation of three variables.



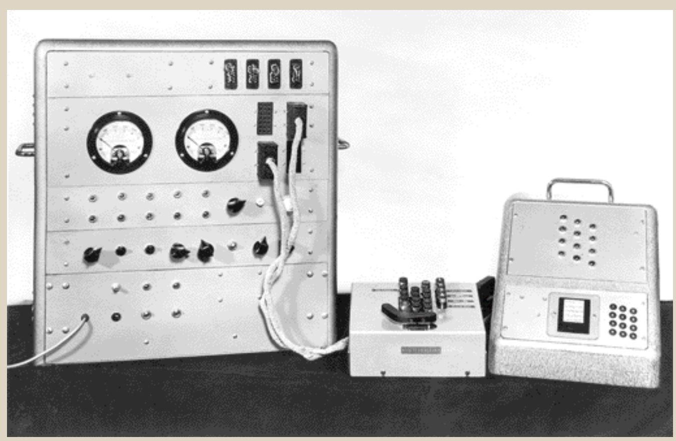
Believed to be an instrumentation panel from the Eucrates project (1955), Gordon Pask developed the system with Robin McKinnon-Wood and CEG Bailey to simulate the relationship between teacher and student. His use of variables for concepts like 'awareness', 'obstinacy' and 'oblivescence' are core to the system.

First, a record is kept for each individual item being studied with regard to the amount of time a student takes to complete this item; a student is able to return more frequently to those problems he or she finds most difficult. Second, a limited period of time is provided to respond to a query. If a student answers a query correctly, then the next time that item is tested the student is allowed less time to respond. If, however, the response is incorrect, the allowed response time for that item is subsequently increased. Third, a cue is given after a certain amount of time if there has been no response from the student. The delay for displaying this cue increases the next time this item is displayed as a student returns correct responses, and decreases as he or she returns incorrect responses. At a certain point, when a student is proficient enough with a single item, this period will be greater than the allowed response period and the student will no longer be provided with a cue.

The result is that, while presentation of test items starts out at the same rate for each item with timely cue information, gradually, as the student improves, the pace is increased and cues are withdrawn for particular items. If a student has difficulty with any individual item – manifested either by making a mistake or by responding slowly – the pace is decreased for that item alone and cue information is selectively reintroduced.

At any point, the machine responds not just to the student's actual input, but also changes the way it responds on the basis of past interactions (sometimes providing cue information, sometimes not; sometimes allowing enough time to answer, at other times cutting it back). The student responds to the machine just as the machine is responding to the student, and the nature of their goals at any point in time is dependent on the particular history of response the other has provided.

For an architecture built on sensors and actuators, SAKI provides a pragmatic strategy for constructing algorithms that have multiple dynamic environmental inputs and outputs, yet



Gordon Pask and Robin McKinnon-Wood, Self-Adaptive Keyboard Instructor (SAKI), 1956
The computing unit is on the left, the middle box is the keyboard the pupil uses to make entries, and the unit on the right displays prompts and cue information.

one that is still able to account for an explicitly human contribution. It provides a model of interaction where an individual can directly adjust the way that a machine responds to him or her so that they can converge on a mutually agreeable nature of feedback: an architecture that learns from the inhabitant just as the inhabitant learns from the architecture.

Chemical computers are assemblages constructed electrochemically, that are able to compute an electrical output on the basis of electrical input. In 1958 Pask was particularly interested in how these could be used to construct analogue systems that emulated biological neural networks in their lack of specificity: they evolved behaviours over time depending on how they were trained. Such systems can modify their systemic interconnections as they grow in order to improve proficiency at calculation or pattern recognition. In effect, Pask discovered that they can grow their own sensors.

He achieved this by growing threads using a known technique of inserting powered electrodes into alcohol solutions of tin and silver. Tendrils would grow from one electrode to another, or to several if several electrodes were powered. Once a thread was broken it would spontaneously rebuild and reconfigure itself, with the break moving up the course of the thread. A sensor electrode was inserted into the thread in order to measure the output waveform generated by this arrangement.

The fascinating innovation Pask made was to reward the system with an influx of free metal ions – which enable growth of the threads – when certain output criteria were met (as measured at the electrode). The arrangement was so delicate that it was affected by all sorts of inputs including, but not limited to, physical vibration. Though several methods were employed, one in particular is interesting for its potential architectural application as an adaptive environment sensing system. A buzzer was sounded. At the moment of sounding, if the frequency of the buzzer appeared at the sensor electrode, then the system was rewarded with its metal ions. Particular arrangements of thread did occasionally detect the buzzer and replicate the electrical frequency at the sensor electrode.

As a result of the reward system – the provision of metal ions – these types of networks were allowed to survive and prosper while those that did not respond to the buzzer were starved of ions and tended to die off. In other words, by measuring the output criteria (the generated waveform) and rewarding the system when these output criteria correlated with specific input criteria (the buzzer sound), the system became better at recognising the buzzer.

The system was therefore able to evolve its own sound sensor, which would not have been possible if all components of the system had been well specified at the start of the experiment because designing and building such chemical structures would have been prohibitively complex. The underspecification of the threads meant that a much better sound sensor could be evolved and constructed. More importantly though, by changing the input criteria, say by using electromagnetic fields rather than vibration, the system could dynamically grow a new type of sensor.

The reasoning behind Pask's interest in underspecified goals is that if a designer specifies all parts of a design and hence all behaviours that the constituent parts can conceivably have at the beginning, then the eventual identity and functioning of that design will be limited by what the designer can predict. It is therefore closed to novelty and can only respond to preconceptions that were explicitly or implicitly built into it.[9] If, on the other hand, a designed construct can choose what it senses, either by having ill-defined sensors or by dynamically determining its own perceptual categories, then it moves a step closer to true autonomy which would be required in an authentically interactive system. In an environmental sense, the human component of interaction then becomes crucial because a person involved in determining input/output criteria is productively engaging in conversations with his or her environment.

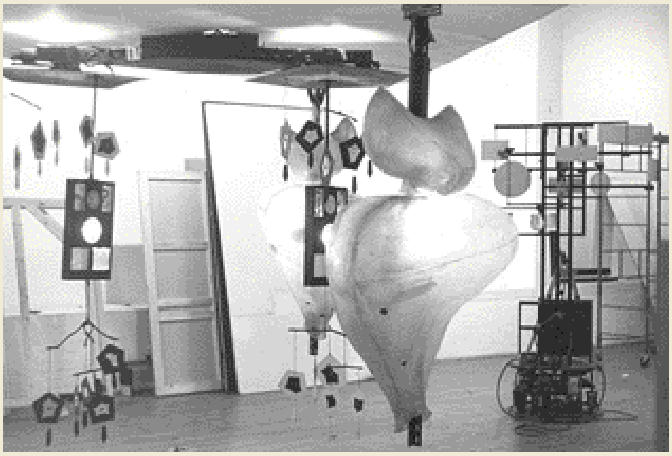
In effect, if such an embodiment has underspecified goals, it enables us to collaborate and converge on shared goals. We are able to affect both the embodiment's response and the way the response is computed.

This is a completely different notion of interaction from that used in many of today's so-called interactive systems, which are premised on unproductive and prespecified circular, deterministic reactions. In these systems, the machine contains a finite amount of information and the human simply navigates through an emerging landscape to uncover it all. I do something, the device/object/environment does something back to me; I do something else, the environment does something else back to me. The human is at the mercy of the machine and its inherent, preconfigured logical system. There is little of the conversation that a truly interactive environment should have, especially in the sense that nothing novel can emerge because all possible responses are already programmed.

The approach of these works is actually rooted in a 19th-century causal and deterministic philosophy that is easy to comprehend in the short term (because it relies on a causal relationship between human and machine – I do X, therefore machine does Y back to me), but is unsustainable in the long term because it is unable to respond to novel or unpredictable situations. Pask was more interested in creating evolving and variable interactions whose sum total is conversational in a valid sense. It is not about concealing and then revealing, but rather about creating information, just as Wikipedia enables in the context of the Web.

In an architectural context, this approach enables us to converge, agree on and thereby share each others' conceptual models of a space and what adaptations we decide it requires. With this shared conception we are better able to act upon the givens of a space in conjunction with an artefact, and do so in a constructive, engaging and ultimately satisfying manner. Such a system has to operate with underspecified

Part of Gordon Pask's Colloquy of Mobiles, showing the two 'male' figures on the left side and two of the three 'female' figures on the right. The work at the back is Peter Zinovieff's Music Computer.



Gordon Pask, Colloquy of Mobiles, ICA, London, 1968
The system was installed at the seminal exhibition 'Cybernetic Serendipity'; the 'female' bulbous forms here were designed by Yolanda Sonnabend.

sensors – either a whole collection of them, each individual sensor of which may or may not eventually be determined as useful in calculating its output and therefore rewarded by the system – or better yet, it may evolve its own sensors, through dynamically determined input criteria.[10]

In his Colloquy of Mobiles project (1968),[11] a physically constructed embodiment of Conversation Theory, Pask suspended a collection of purpose-built mechanical artefacts able to move and rotate, some directing beams of light ('females') and others using a combination of servos and mirrors to reflect light ('males').

Movement was initially random until a light beam from a female was caught by a male and reflected back to the female's light sensor. At this point, movement would cease and the light beams were locked in place as the males started oscillating their mirrors. After a period of time, the mobiles would start moving again, searching for new equilibrium arrangements.

If left alone, the males and females would continue an elaborate and complex choreography of conversations through the medium of light – one which it was not necessary or even possible to preprogramme – finding coherence every now and then as a light beam was shared between partner members of a conversation. The most interesting point came when visitors entered the scene. Some blocked pathways of light while others used handheld torches to synchronise the devices. The males and females were not able to distinguish between light created by a visitor and light reflected from a female – and had no need to. They were still able to find coherence within their own terms of reference.

Colloquy reminds us that environmental sensor/actuator systems (light beams in this case) will respond to their environment solely on their own terms. For example, a thermostat's measurement of and action upon temperature is predetermined by the designer's conceptions and is thus predicated on various assumptions, assumptions of our desire for a consistent ambient room temperature – that we know what 21°C is, that we will not feel the fluctuations of thermal hysteresis within limits of 3°C per minute.

This makes sense for something as easy to learn and understand as a thermostat, in which there is a finite range of input conditions and a finite range of output conditions and the system attempts to map from inputs to outputs in a linear-causal way. However, it becomes problematic in complex environmental systems such as those that take into account weather predictions, energy prices and internal conditions, which are able directly to affect sunlight pathways, temperature and humidity, shading and other building management entities without genuinely understanding how Paskian conversations can be beneficial. Yet this is the approach that contemporary ubiquitous computing is taking. Also known as the 'disappearing computer' approach, this discipline aims to hide from us the complexities of technology, but in fact removes what little control we might have had over our environmental conditions and requires us to place all faith in the presumptions of the original system designers.

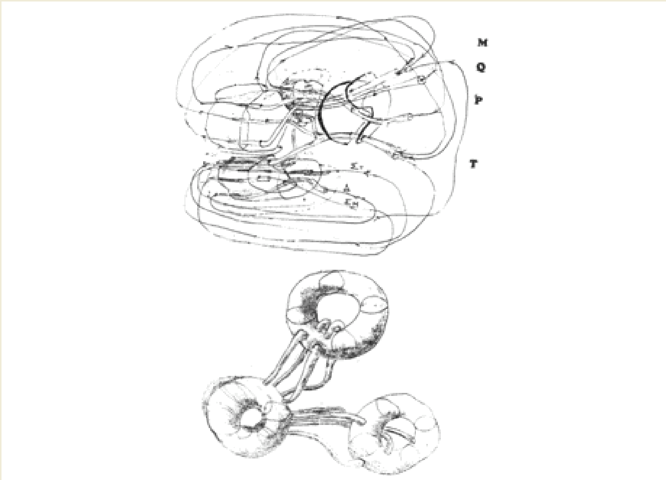
Such environmental systems must contain methods for ensuring that proposed outcomes of the system are actually acceptable to the human. The significant complexity and dimensions of the system must be able to improve outcomes without confounding a person with too many inappropriate or incomprehensible outcomes. Moreover, he or she must have a way to reject inappropriateness and reward those criteria that are useful. A person must be able to construct a model of action collaboratively with the environment.

This makes it clear that we need to be able to make coherent connections with our environmental systems. Rather than simply doing exactly what we tell them (which relies on us knowing exactly what we want within the terms of the machines, terms that are predetermined by the original designer) or alternatively the systems telling us exactly what they think we need (which relies on the environment interpreting our desires, leading to the usual human–machine inequality), a Paskian system would provide us with a method for comparing our conception of spatial conditions with the designed machine's conception of the space.

It is vital at this stage in the development of interactive and time-based media to reconsider Pask's model of interaction, particularly because we are no longer naive in dealing with our technological interfaces. We now expect more from them and are better able to comprehend the structures behind them. A Paskian approach to architecture does not necessarily require complexity of interaction – it relies on the creativity of the person and the machine negotiating across an interface, technological or otherwise.

In his designs, theories and constructions, Pask provides rigorous guidance on how to build such systems, with strict definitions for 'performance', 'conversation', 'interaction', 'environment' and 'participation'.

I concede that simple reactive devices designed to satisfy our creature comforts are useful for functional goals. These include systems such as those employed in Bill Gates'



Pask was rigorous about the use of words such as 'concept', 'coherence' and 'analogy', often using sketches of 3-D toroidal forms to diagram these in the context of interaction, evolution and conversation.

technologically saturated mansion, which tracks visitors' locations to provide them with preset optimised temperatures in each room they enter. They also include building management systems that optimise sunlight distribution, rooms that change colour as people enter them, and facades that represent environmental or internal conditions on their surfaces. These satisfy very particular efficiency criteria that are determined during, and limited by, the design process. However, the key to Pask's innovative underspecified systems is that input criteria are determined dynamically; sometimes, like MusiColour by adjusting the weighting of particular input criteria – varying how important they are in the overall calculation – and sometimes, like the chemical computer, by enabling the system to select or construct its own input criteria.

This is a crucial requirement for making spaces and environments that foster engagement with their occupants. Architectural systems constructed with Paskian strategies allow us to challenge the traditional architectural model of production and consumption that places firm distinctions between designer, builder, client, owner and mere occupant. Instead we can consider architectural systems in which the occupant takes a prime role in configuring and evolving the space he or she inhabits, a bottom-up approach that enables a more productive relationship with our environments and each other. Pask's approach, if implemented, would provide a crucial counterpoint to the current pervasive computing approach that is founded on interaction loops that have been fixed by the designer and, if implemented, would have a positive impact on the design of future environments.

This interpretation of Pask's way of thinking about interactive systems does not necessarily result in technological solutions. It is not about designing aesthetic representations of environmental data, or improving online efficiency or making urban structures more spectacular. Nor is it about making another piece of high-tech lobby art that responds to flows of people moving through the space, which is just as representational, metaphor-encumbered and unchallenging as a polite watercolour landscape.

It is about designing tools that people themselves may use to construct – in the widest sense of the word – their environments and as a result build their own sense of agency. It is about developing ways in which people themselves can become more engaged with, and ultimately responsible for, the spaces they inhabit. It is about investing the production of architecture with the poetries of its inhabitants. ⌂D

I would like to thank Dr Paul Pangaro for giving comments during the preparation of this article.

Notes

1 Quoted in Mary Catherine Bateson, *Our Own Metaphor: A Personal Account of a Conference on the Effects of Conscious Purpose on Human Adaptation*, Alfred A Knopf (New York), 1972.

2 See, for example, recent attempts to replicate Gordon Pask's electrochemical experiments by Peter Cariani, Tufts Medical School; collaborations by Jon Bird, University of Sussex and artist Andy Webster; Dendrite by architect Pablo Miranda, Royal Institute of Technology, Stockholm; Cornell University professor Maria Fernández, writing about Reichardt's 'Cybernetic Serendipity' exhibition at London ICA with special emphasis on Pask's installations; Andrew Pickering, historian of science from University of Illinois, preparing a book on English cyberneticians; collaboration between Omar Khan, Buffalo University and Raoul Bunschoten, Architecture Association, London.

3 Even now his archives (in both Europe and North America) have not been fully classified, though his UK archive has recently been transferred to Vienna.

4 Nicholas Negroponte, *Soft Architecture Machines*, MIT Press (Cambridge, MA), 1976.

5 In this context it is important to note the enormous contribution that Robin McKinnon-Wood, friend, collaborator and business partner, made to Pask's work; he built and helped design several of the Paskian machines described here. For more on this collaboration see Ranulph Glanville, 'Robin McKinnon-Wood and Gordon Pask: a lifelong conversation', originally published in the *Journal of Cybernetics and Human Learning*, Vol 3, No 4, 1996, now available online at www.imprint.co.uk/C&HK/vol3/v3-4rg.htm.

6 Gordon Pask, 'A Comment, a case history, a plan', in Jasia Reichardt, *Cybernetics, Art and Ideas*, Studio Vista (London), 1971, pp 76–99, provides a good description of the project.

7 ibid.

8 See Gordon Pask, 'SAKI: 25 years of adaptive training into the microprocessor era', in *International Journal of Man-Machine Studies*, Vol 17, 1982, pp 69–74.

9 'Sensors and effectors determine how events in the world at large are related to the internal informational states of organisms and robotic devices. Sensors determine what kinds of distinctions (perceptual categories, features, primitives) can be made on the environment. By "evolving the sensor" perceptual repertoires can be adaptively altered and/or enlarged. To the extent that devices can adaptively choose their own feature primitives for themselves, they gain a greater measure of "epistemic autonom" vis-à-vis their designers. Such devices are useful in ill-defined situations where the designer does not know a priori what feature primitives are adequate or optimum for solving a particular task. From Peter Cariani, 'Epistemic autonomy through adaptive sensing', *Proceedings of the 1998 IEEE ISIC/CRA/ISAS Joint Conference*, IEEE (Gaithersburg, MD), 1998, pp 718–23. An expert on Paskian systems, Cariani has reconstructed Pask's sound-sensing chemical computer.

10 For more on this see 'Distinguishing Concepts: Lexicons of Interactive Art and Architecture' also in this volume.

11 See Jasia Reichardt, *Cybernetic Serendipity, Studio International* special issue, London, 1968.