Computing, Design, Art: Reflections on an Innovative Moment in History

Stephen Boyd Davis, Simone Gristwood

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Stephen Boyd Davis[1] and Simone Gristwood[2]

[1]Royal College of Art, London, United Kingdom
stephen.boyd-davis@rca.ac.uk
[2]Middlesex University, London, United Kingdom
s.gristwood@mdx.ac.uk

Abstract. The paper is concerned with the role of art and design in the history and philosophy of computing, and the role of computing in models of design and art. It offers insights arising from research into a period in the 1960s and 70s, particularly in the UK, when computing became more available to artists and designers, focusing on Bruce Archer (1922-2005) and John Lansdown (1929-1999) in London. It suggests that models of computing interacted with conceptualisations of art, design and creative activities in important ways.

1 Introduction

Our paper is concerned with the role of art and design in the history and philosophy of computing, and the role of computing in models of design and art. We offer insights arising from our research into a period in the 1960s and 70s, particularly in the UK, when computing became more available to artists and designers, focusing on Bruce Archer (1922-2005) and John Lansdown (1929-1999) in London. Our sources are archives[1] and interviews.

Neither Archer nor Lansdown saw any incompatibility between the mechanistic processes of computing and the creative worlds of design, art, composition, choreography and related disciplines. Indeed they embraced the challenge of the machine in these apparently intuitive, humanistic fields. Such approaches have their roots far back in the history of computing: Babbage identified two qualitatively different applications of complex machinery. The Difference and Analytical Engines were machines primarily for useful work – but Babbage's prized possessions included an automaton dancer and a portrait of Joseph Marie Jacquard woven on a Jacquard loom. For Babbage, these two items represented the idea that apparently humanistic, artistic creations could be arrived at by mechanical means [1 p.107]. The Analytical Engine was an advance on the Difference Engine not least because, when it 'weaves algebraical

[1] The L Bruce Archer Archive at the Royal College of Art (RCA), the RCA College Archives, the archives of the Department of Design Research (RCA) at the Victoria and Albert Museum, the John Lansdown Archive (JLA) at Middlesex University, and the Design Archive at University of Brighton.

patterns just as the Jacquard-loom weaves flowers and leaves' [2], mathematics is conceived as philosophical inquiry not as functional work. So, from the earliest days of computing its potential application to creative and humanistic fields was discussed. A century later, these questions were addressed afresh by Archer, Lansdown and others through art and design. Subsequently, much art and design thinking has been dominated by the notion of the computer as merely a tool, no more important intellectually than a trowel, an airbrush or a scalpel: our aim is to examine how more profound ideas of computing affected models of the design process and were in turn reconsidered in the light of creative practice.

Lansdown and Archer were working at a time of great optimism about computers internationally. Important influences on both were mid-century ideas on information theory, systems theory, operational research (OR), organization and methods (O&M) and cybernetics. OR appealed to Lansdown because it offered systematic decision-making using mathematical and statistical approaches. Applied to design, it emphasized sequential processes such as gathering data and requirements, weighting these before proceeding to designing. A similar interest led Archer to computing, as he saw its logic as a way of generating 'effective systematic methods for solving design problems' [3 p.1]. Archer's publications *Systematic Method for Designers* (1963-64) [4] and *The Structure of Design Processes* (his doctoral thesis of 1968) [5] show a strong influence of algorithmic thinking.

Things became interesting when Archer and Lansdown each considered linear algorithmic models of designing in the light of actual practice in design and the arts. A crucial realisation was that effective designing cannot occur where the requirements-gathering process is effectively closed before designing begins. Cybernetics, with its emphasis on feedback and auto-reconfiguring seemed important: Archer cites Wiener, Beer, Pask and Ashby in his thesis, arguing that, as designing proceeds, it always raises unforeseen requirements, questions and information needs. Interactivity in and around computer-based design systems attracted both Archer and Lansdown, as a partial solution to this problem, but also as a deeper model of how designing is done.

While Archer's preoccupation was primarily with design and design education, Lansdown's interest ranged wider, with work spanning architecture, computer graphics, choreography, design education and artificial intelligence. A founder member of the Computer Arts Society, he edited their newsletter, *PAGE*, which engaged internationally with discussions about computers in the arts in the broadest sense. He also wrote a regular column from 1974 to 1992 for the *Computer Bulletin* that provides a unique insight into his thinking and that of his contemporaries. For him, computing could among other roles be a simulator, creative interlocutor, expert system, or information environment. An important landmark was his work on computer-generated choreography, discussed below.

Lansdown and Archer had influential roles, each leading a pioneering research centre in his university; through publication, and their senior advisory roles on the UK Science Research Council and Design Council respectively, they affected policy on computing, design, design management, the arts and other fields. Archer retired from the RCA in 1988. Lansdown continued until his death in 1999 to champion the idea that computing was not just a medium or tool, but an intellectual challenge whose possibilities deserve active, ostensive investigation.

2 Bruce Archer

At the Royal College of Art (RCA) for 27 years, Leonard Bruce Archer was a key figure in early Design Research and a driving force behind the attempt in the 1960s to be rigorous, and in particular 'systematic', about the nature and practice of designing. He sought to establish a philosophy of design [6: p.33], even a 'science of design' [5: Foreword], a phrase often associated with Simon's *Sciences of the Artificial* [7]. Essential to this science was 'design research', understood not only as the study of methods, but also of design's ontology as a discipline and an activity. From the outset, the attempt to systematize design according to mechanistic principles was controversial: two figures who initially embraced such an approach soon became opponents, J Christopher Jones [8] and Christopher Alexander,[2] the latter commenting, 'people who are messing around with computers have obviously become interested in some kind of toy. They have very definitely lost the motivation for making better buildings' [9].

Archer worked at the RCA from 1962 as a researcher in Industrial Design, later Research Professor of the Department of Design Research (DDR) in 1972-73. Previously he had worked briefly at the Hochschule für Gestaltung Ulm with design theorist Horst Rittel among others. His own education had been in mechanical engineering, though when younger he had wanted to be a painter. By 1953 he was an engineering consultant and was teaching evening classes at London's Central School of Art and Design; he was full-time there by 1957. He wrote articles for *Design* magazine from 1954, promoting what he called 'a rational approach to design.' Together with his 1968 doctoral thesis, these provide a valuable record of his developing thought including his influential seven articles 'Systematic method for designers' republished as an offprint by the UK Design Council in 1965 due to demand.

Archer's earliest *Design* articles, beginning 1954 [10,11] argue the importance of both creative invention and profound technical knowledge in an industrial designer. In four articles from 1956 he again argues against purely technical engineers working by rule of thumb: the industrial designer must be informed by both art and science [12]. Design Research includes the calculation of the bounding space of optimal solutions, based on data about requirements, materials and production methods – later a key part of his doctoral thesis (**Fig. 1.**).

At the RCA, Archer became involved in large, complex design projects – most notably a fundamental redesign of the NHS hospital bed [13]. During the project, the team had to deal with intersecting issues of manufacturing, materials, healthcare, hands-on nursing, standards, safety, hospital management, patient satisfaction, indus-

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[2] Both Jones and Alexander presented papers at the Conference on Design Methods held at Imperial College, London in September 1962, a founding event of Design Research as a discipline. Archer was present and was a member of the organizing committee. At that time all three figures broadly agreed about the need for system and rigour in designing.

trial commerce, external relations, institutional culture and politics at a number of levels. Such experience modified Archer's thinking and led him to question the simplicity of his original model of designing [14].

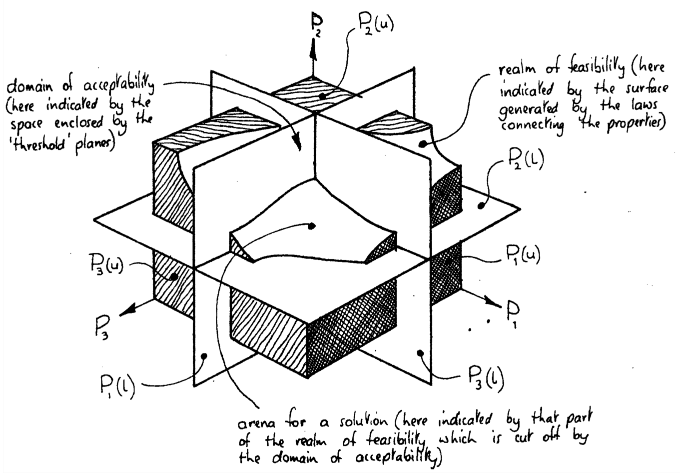

Fig. 1. From Archer's 1968 doctoral thesis (Figure 2.18) illustrating how 'the interdependence of the curves of feasible mutual states will constitute an n-dimensional hypersurface or realm of feasibility. An important pre-requisite for an ultimate solution is that at least a portion of the realm of feasibility should intersect the domain of acceptability, producing an arena within which a solution must be found' [5: §2.27]. L Bruce Archer Archive, RCA, London

At a practical level, Archer was keen to exploit computing to assist in the design task. In 1964 it was stated that, 'In recent years Mr Archer has devoted himself to the development of a system of logic for the solution of design problems and has become deeply involved in the application of computer techniques' [15]. This was not always trouble-free: an archive document from 1966 [16] is a review of practical problems in using the Atlas computer at Manchester Institute of Science and Technology, and difficulties in agreeing with A.J. Willmott of the Department of Computation there how to approach the task. Yet, even when the actual use of computing was not effective, Archer was attracted to it as a possible model: 'Now in 99 cases out of 100 it would not be an economic proposition to do any computerising on a design decision, but having seen how it could be done on a computer I then have a very much better idea of how it goes on in our own personal computers [ie. our brains]' [17].

Next year he wrote, 'the logic by which computers work, and the clarity and fullness of expression which is necessary to prepare a real-world problem for computing, are valuable indicators of the sort of logic which might work even without a computer' [3]. This linear approach – in which problem definition and data-gathering are completed before a (possibly iterative) design process – was in many ways just what appealed to Archer, Jones and many others **(Fig. 2)**. They were stimulated by the need to be explicit about the problem they were trying to solve and by the need for data at the outset. But other models would also claim Archer's attention, discussed below.

2.1 Archer's 1968 Doctoral Thesis

By the time Archer wrote *Systematic Method* and his thesis (completed when he was forty-six), he was increasingly optimistic about a science of design. Now little is said about the need for creative input – he emphasises the power of a range of scientific disciplines. Titles in his thesis bibliography are illuminating, including Ackoff's *Scientific Method; Optimising Applied Research Decisions* [18]; Boulding's *General Systems Theory, Skeleton of a Science* [19]; Churchman's *Prediction and Optimal Decision* [20]; Latham's *Problem Analysis by Logical approach* [21]; and Pessemier's *New Product Decisions: an Analytical Approach* [22]. This was a period of high optimism about rational methods, systematic thinking and calculation. Operational Research (OR) and Organisation and Methods (O&M) were seen to have yielded significant benefits in war [23] and administration [24]. Archer is unequivocal: 'A logical model of the design process is developed, and a terminology and notation is adopted, which is intended to be compatible with the neighbouring disciplines of management science and operational research. Many of the concepts and techniques presented are, indeed, derived from those disciplines' [5: Foreword].

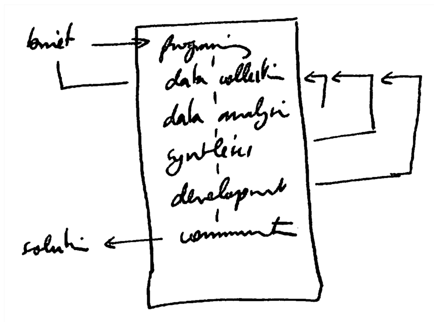

Fig. 2. 'Simplified checklist' from Archer's handwritten notes entitled 'Lecture for London College of Furniture 25 Feb 1965 Systematic method 1 – Introduction.' The brief precedes and lies outside the design cycle. L Bruce Archer Archive, RCA, London: box 2.1.2.

The ideal model, to which Archer and others were initially attracted – in which requirements are finalised prior to designing which then proceeds in an orderly manner without need for reconsideration of the objectives – shows a number of signs of disturbance in the thesis. Surely the fact that Archer had managed and studied the horribly complex Hospital Bed and other live projects, rather than simply observing designing at a distance, must have made him more aware of the messiness – and the embodied nature – of real world design?

2.2 From Linearity to Cybernetics

One key reason to question the simple systematic method was the interdependence of factors. Fixing one problem opens another and unforeseen consequences occur, problems of complexity characteristic of socio-technical systems [25: p.120]. Archer's colleague at Ulm, Horst Rittel, memorably characterised these as ‘wicked problems’ in dialogue with C West Churchman at just the time Archer was finalising his thesis. Both authors feature in the thesis [20,26], and Archer explicitly notes the role of dependence [5: endnote 60].

Despite diagrams like **Fig. 2** that appear to show the brief lying outside and prior to the design process, Archer actually acknowledges at several points in his thesis, that the requirements which the designers thought they were working to may be subject to revision at any point. ‘During the course of the problem solving activity new objectives may tend to form and reform’ [5: §2.29]; ‘The complete set of objectives is only rarely definable at the beginning of the project. Most of them emerge by mutual consent as the project progresses’ (§6:15); ‘any effective design procedure must therefore permit *radical reappraisal of the problem at any stage*.’ (§6:17, emphasis added).

OR and O&M both depended on adequate data in order to be effective. Yet in key areas that Archer considered essential to design, including aesthetics, he acknowledges the lack of good data. He bemoans the lack of ‘a corpus of knowledge or a set of techniques capable of providing rational aesthetic decisions’ (§8:17).

Three disruptions thus threaten the systematic model: complexity, the fluidity and instability of requirements, and the lack of data to support key decisions. Simple OR, O&M and linear design models seemed not to offer appropriate answers. However, two other key discipline areas, both evident in Archer’s thesis, offer possible solutions: game theory and cybernetics – disciplines that both deal with on-going, unpredictable, dynamic systems having emergent properties, quite distinct from the pipeline model that seemed fundamental to Archer’s system. As Pickering puts it, ‘cybernetics grabs on to the world differently from the classical sciences. While the latter seek to pin the world down in timeless representations, cybernetics directly thematizes the unpredictable liveliness of the world, and processes of open-ended becoming’ [27]. Two UK cyberneticians in particular are relevant to Archer’s problems of complexity and uncertainty – Ashby and Pask. Ashby comments on the three Archer problems of complexity, instability of requirements, and inadequate data. He notes how complexity had been avoided traditionally: not until the 1920s ‘did it become clearly recognised that there are complex systems that just do not allow the varying of only one factor at a time – they are so dynamic and interconnected that the alteration of one factor immediately acts as cause to evoke alterations in others, perhaps in a great many others’ [28: p.5]; ‘Often, however, the knowledge is not, for whatever reason, complete. Then the prediction has to be undertaken on incomplete knowledge, and may prove mistaken’ (p.111). Pask also discusses situations ‘where the objective is not obvious at the outset and only becomes so when some tentative knowledge has been gained’ [29: p.19]; ‘uncertainty stems from ourselves and our contact with the World’ (p.21). Perhaps this remark of Pask’s appealed to Archer after the tribulations of managing complex practical projects: ‘Cybernetics offers a scientific approach to the cussedness of organisms, suggests how their behaviours can be catalysed and the mystique and rule of thumb banished’ (p.110).

At the opening of the 1960s, Archer’s key insights focused on the uses of science and on linear algorithmic processes – not only as a means of getting design done, but also as models of how Design as a discipline might work at a deeper level. OR and

O&M seemed at first inspirational. By the close of the 70s, Archer, perhaps reluctantly, acknowledged that game theory and cybernetics had much to offer as models of designing. Well-defined sub-problems might still be susceptible to batch-wise computation, but Archer's attention increasingly turned to interactive systems such as SAMMIE developed at Nottingham University. In January 1973, *Design* magazine reported that a new Centre at the RCA was linked directly to the Atlas II computer of the Computer Aided Design Centre at Cambridge (set up in 1969); and that Archer had been awarded £11,700 by the Science Research Council to evaluate and develop modelling techniques, including SAMMIE, for equipment designers. Again for Archer these were not just practical tools, but views onto the kinds of knowledge – and knowledge systems – that design requires.

Later Archer felt that he had 'wasted a lot of time trying to bend the methods of operational research and management techniques to design purposes' [30]. He now offered a dramatically different approach: instead of trying to subsume design within science, he proposed that humanities, science and design are equals in a triad of disciplines: 'there exists an under-recognised but definable *third area* of human knowing, additional to numeracy and literacy' [31: Foreword, emphasis added]. Nevertheless, his advocacy of the use of evidence in design, of rigorous analysis, of user-centred research that seeks to balance the conflicting needs of multiple stakeholders, and of the need for designers and engineers to mistrust custom-and-practice and rule-of-thumb, are vital legacies of his initial attempt to scientise design.

3 John Lansdown

Robert John Lansdown (1929-1999) was connected with Archer in several ways. As an adviser to the Science Research Council he supported Archer's moves to employ computing in the design process; his friend and colleague George Mallen was a key figure in the development of computer use within the DDR at the RCA; Lansdown eventually worked at the DDR under Archer from 1983 to 1986. But long before this he played a wide-ranging role in philosophising the relationship of computing to art and design. Like Archer, he was a natural questioner of the status quo. Reflecting on his career in 1988, he remarked that 'I wanted them to challenge the accepted ways of doing things and I am still very much in favour of this' [32].

Lansdown graduated from the Welsh school of Architecture in 1951, and became a partner in the architectural practice Turner, Lansdown, Holt and Paterson in 1955. In 1960 the partners began looking into the relevance of other disciplines: Lansdown chose operational research and mathematics. This led him to computing, and in 1964 he joined the young British Computer Society (BCS). In 1965 he became a fellow of the RIBA, and in 1968 he co-founded the BCS Computer Arts Society with George Mallen and Alan Sutcliffe. Throughout the 1970s, 80s and 90s Lansdown was involved in committees, organisations and roles contributing to the use of computing in the arts and design, including the Science Research Council's Computer Aided Building Design panel. His involvement in areas of computing in art and design tended to transcend traditional distinctions between subjects (such boundary-crossing was a characteristic of cybernetics according to Pask). In the arts, Lansdown chaired and organized many international conferences and events: *Event One* at the Royal College of Art (1969) and *Interact* at the Edinburgh Festival (1973) were seminal events in establishing the use of computers for the creation and implementation of art works. And from 1974 to 1992 he wrote a column in *Computer Bulletin* entitled 'Not Only Computing, Also Art'. He published widely in fields such as computer graphics, computer animation, CAD and architecture, and his work along with colleagues involved computer graphics for film and advertising, including for the feature film *Alien* (1979) and even for toothpaste adverts in the 1980s.

Like Archer, Lansdown moved from linear, problem-solving approaches to a richer, more complex model of designing and creative work. Lansdown recalled that in his formative years as an architecture pupil 'his fascination with algorithms [was] down to an inherent interest in processes and step-by-step procedures, from his school days drawing maps and memorizing shapes in nautical school' [32]. It was the appeal of step-by step procedures that inspired his initial use of computers. However, his thoughts about their use developed quickly, particularly when applied to art and design, where he investigated how computing could support creativity – challenging the idea, in disciplines such as architecture, that computing was not compatible with creative work [33]. In the 1960s, only a very small proportion of the architecture profession used computers [34] yet Lansdown was already noted for his skills in programming [ibid.].[3]

3.1 Lansdown's Early Mathematical Studies

Queuing and Waiting, a 30-page typed study from 1963 [35], exemplifies Lansdown's early mathematical studies for architecture. Here he sets out a 'general outline of the methods of analysing congestion generating systems' (p.1) and explores the widespread application of queuing and congestion theory to planning. 'Car parks', 'telephone boxes' and 'narrow doorway' are defined as *systems*, together with the units that constitute the queue (cars; callers; opposing stream of people), the demand, and the provision required to satisfy that demand. This kind of study was becoming more common, which Greenwald-Katz attributes to 'limited resources planning' [36: p.317] in which it was the job of the architect or designer to 'deal responsibly with energy, time, money, land and space'. Lansdown later often used the surprising mathematics of queuing to illustrate the inadequacy of common-sense and intuitive approaches, echoing Archer's demand that engineers and designers cease their dependence on custom and intuition and get up to date with the technical state of their subject.

By 1964, Lansdown's architecture practice was considering using computers for a range of applications, including engineering (stormwater drainage calculations, road design etc.), planning (analysis of population statistics, logical analysis of Client's brief, etc) and management (scheduling and throughput of drawing office work, simu-

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3 An important distinction between the capabilities of Archer and Lansdown was that Lansdown had hands-on programming skills, equipping him to undertake his own experiments pushing the boundaries of algorithmic approaches to creativity.

lation and management games, etc.). This work was undertaken using batch processing; by 1967 the company had moved to a timesharing system. In principle it was based on mathematically calculating solutions to well-defined problems. As noted above, this was at the time a dominant model, not only of computing itself, but of processes seen as analogous, including design, which the early Design Methods movement generally regarded as a problem-solving activity.

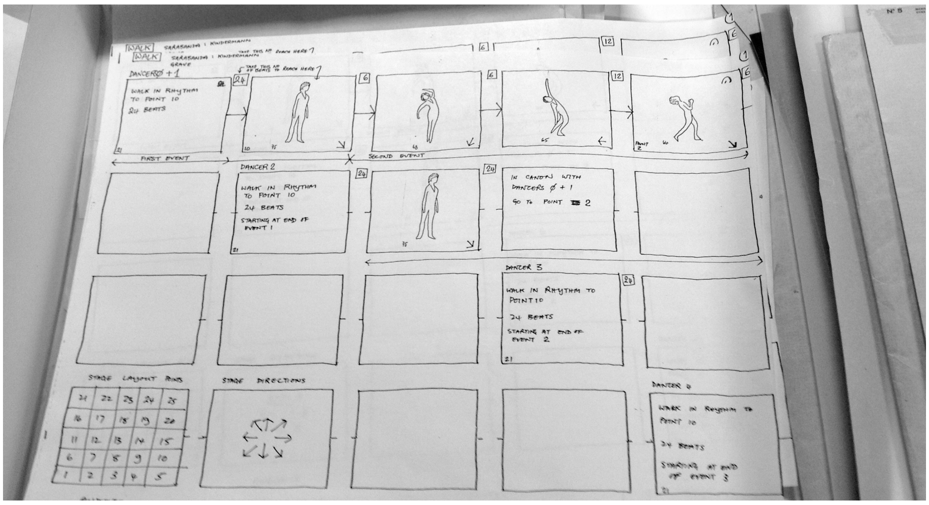

Fig. 3. A hand drawn planning-sheet used by Lansdown as part of his computer-based choreography activities. John Lansdown Archive, Middlesex University, London: uncatalogued (n.d., c1970s).

3.2 Lansdown's Experiments in Art

By the late 1960s Lansdown had branched out into new areas. This was an experimental time for artists using computers across the world, with the first exhibitions and computer art competitions such as *Generative Computergrafik* (1965) in Germany, and *Computer-Generated Pictures* (1965) in New York, *Cybernetic Serendipity* (1968) at the ICA in London, *Event 1* (1969) at the RCA, and *New Tendencies* from 1968 in Croatia, as well as the *Venice Biennale* computer arts exhibitions. There were connections between the arts, design and computing through figures such as German philosopher Max Bense, who was not only involved in one of the first computer arts exhibitions in Stuttgart in 1965, but also taught at Ulm in the 1950s where, as noted, Archer was a visiting scholar from 1960 to 62.

Lansdown, like others including A Michael Noll of Bell Labs, became interested in computer choreography – though in differing ways. Whereas Noll choreographed dancing figures on screen, Lansdown programmed computers to create dance notation to be performed by human dancers. From about 1962, 'familiar with some of the attempts to utilize the computer to compose poetry or prose, to produce kinetic sculpture, or to create music, I tried to draw common principles from these efforts to apply to ballet' [37: p.19]. Lansdown acknowledged that following step-by-step procedures was one way to explore computing in the arts and that part of the 'the appeal of computer art lies in the procedures used to produce it – *the computer methods used are as interesting to the artist as the final outcome*' (op. cit. p.21, emphasis added). These procedures could be deterministic or might include stochastic (pseudo-random) elements, and in general, would be too complex to carry out easily by hand. Such an approach illustrates Lansdown's fascination with algorithmic thinking. He was quite aware of difficulties in modelling creative activity, both conceptually and computationally, but was determined to push the boundaries of computing in the arts, in design and in any other field where it might yield new insights. Though Lansdown's experiments in choreography were initially often stochastic, by the late 1970s he had shifted towards more deterministic procedures and interactive co-operation with dancers. The instructions were intended to 'provide a framework within which the dancers are to compose simple patterns of movements' [38: p.10].

Fig. 4. Lansdown's experiments increasingly explored a triadic interaction: Lansdown himself, his program and the dancers. Royal Ballet Company dancers Lesley Collier and Marilyn Thompson with John Lansdown, 23 May 1969. Photo: Trinity Mirror / Mirrorpix / Alamy.

Lansdown's computer choreography included generating scripts for sword fights and for 'custard pie routines', and working with various dance groups and dancers who successfully performed his work in the UK and Europe, and later in Australia, from the late 1960s through to the 1990s. His work was presented at the first Computer Arts Society exhibition *Event One* in March 1969 at the RCA, and was filmed by the BBC for the popular programme *Tomorrow's World* [39]. The commentary concludes with the words, 'A computer that plans a sword-fight, a computer that writes a ballet. Without the added creative skill of the human eye, the work produced by a computer is – so far anyway – a dead and soulless thing,' an opinion with which Lansdown would have disagreed. For example, he discussed a key difference between two methods within algorithmic choreography:

> One is to have a more or less clear idea of the dance we wish to create and then devise an algorithm or algorithms to realise it. We can call this, the 'computer-assisted approach.' The other is to have a more or less clear idea of the algorithm we wish to create and then to see what sort of dance it produces. We can call this, the 'computer-generated approach.' Clearly, these are entirely different and my interest in the last 25 years or so has been in the latter [40].

It is clear from such remarks that the computer is seen as an active participant, and that the outcome of the evolving triadic relationship between Lansdown, his program and the dancers is a truly interactive one. By now Lansdown was a long way from Page's pessimistic assessment at the 1962 Conference on Design Methods:

> The digital computer obviously has its place, particularly for solving well established type problems, for example structural design, but I think that computers contribute practically nil to creative design [41].

Lansdown commented in 1977 that 'The dances… illustrate an approach to creativity different from the conventional and, significantly, make use of a technique so familiar to some ballet critics in Britain they rarely find it necessary to comment on the fact a computer has been used' [38]. By the 1990s his work, recognised as programmed by computer, was receiving much critical acclaim – as numerous press clippings in the archive attest.

The journey from *Queuing and Waiting* to computer choreography demonstrates Lansdown's shift from step-by-step problem-solving to an increasing interest in interactive process. His insights crossed disciplinary boundaries well beyond the field of choreography, and echo the observations of Archer:

> Design is not an algorithmic process in which the designed conclusions can be reached by the operation of step-by-step procedures – first finalising this aspect, then that. It is a fluid, holistic process wherein at any stage all the major parts have to be manipulated at once [42: p.3].

The computer was clearly for him far more than a mere tool: it was a medium, 'an implement of directed experimentation' and even 'more or less an intelligent assistant' [43: p.14].

4 Questions of Computing and Art and Design

Archer and Lansdown were figures of their time. Lansdown acknowledged the alignment of his choreographic work with 'the trend in other areas of computer art' [38]. But they were also leaders pushing at the boundaries of theory and practice. In particular they helped to shift focus away from the final artefact and towards the systems involved in conception, development and enactment. In the art world, this was paralleled by contemporary movements such as process art and Fluxus [43]. In design, as we have seen, models included both problem-solving such as OR, and more complex, interactive models including the cybernetics of Beer, Pask and Ashby. Both Archer and Lansdown found themselves engaged in reflexive processes: not only did computing provide initial inspiration for systematic, process-based and generative models of design and art, but their experience of personally undertaking design direction and artistic development altered their understanding of what computing was and how it should develop. The growth of high-speed interactivity in computing was partly a result of technological advances in interface devices and the constant increase in computing power, but was also an outcome of the kinds of demands placed on computing by designers and artists who wanted to see, manipulate, alter and reconsider within a tight loop of creation, evaluation, reaction and redesign.

Ironically, once computing started to offer highly interactive systems easily usable by any designer, and in particular once computers started to imitate the behaviour of real-world tools and media, some of the innovative spirit was lost. Archer continued to encourage a deeper approach, for example through the teaching of Reffin Smith [45], an RCA research fellow and later a tutor from 1979 to 1984, which prioritised thought processes over mere product. The involvement at the RCA of figures with in-depth knowledge of computing such as Patrick Purcell from 1964 to 1981, George Mallen through the 1970s, and Lansdown himself in the 80s, continued the tradition of philosophical engagement with computing [46]. Lansdown took this approach with him to Middlesex's National Centre for Computer Aided Art and Design in 1988, so that research and teaching there also avoided the superficial imitation of traditional media, not least because so much of the research and teaching continued to involve programming by staff and students.

Key insights that Archer and Lansdown achieved through thinking deeply about – and actively working within – the combination of computing, design and art included:

- Computing can be part of a creative, constructive dialogue with the human designer or artist – not 'just a tool.'
- The brief, the objectives, the requirements, do not precede design – they are an integral part of the design process.
- Abstract models and tidy theories must face up to messy, embodied, contextualized reality. Real-world instantiation is fundamental to designing and to any worthwhile design philosophy.
- Design is a complex process comprising multiple disparate activities set in a social context. Human needs and behaviours are fundamental to the activity of designing, as much as to the use of designed products and systems.

- Knowledge and evidence are essential for effective designing; intuition alone is insufficient to tackle most real-world tasks. The question of how to identify, gather, organise and deliver information is a key issue in the relation between computing and design.[4]
- Design, art, music, choreography, the sciences, are cognate attempts to make sense of the world. Crossing the boundaries of disciplines promotes new insights hard to achieve from within the discipline. Computing facilitates the transfer of principles from one domain to another.
- Perhaps design is not assimilable to the humanities or the sciences, but is a third way of thinking and acting.

Recently, approaches to computing among artists and designers are once again foregrounding the fundamentals of computing, whether in live-coding by musicians and sound artists, 'maker faires', or in increased interest in overtly algorithmic art. There is renewed interest in *systems*, driven by the realisation that designed objects cannot be divorced from the wider systems of research, designing, sourcing, production, use, disposal, repair and reuse. There is a revival of interest in cybernetics, partly through the decades-long work of Glanville (eg. [48]); Mason [49] has suggested that cybernetics was fundamental to computer arts in Britain, a framework for art production that allowed artists to consider new technologies and their impact on life. These developments and their antecedents are important components in the history and philosophy of computing.

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[4] Archer started his work at the RCA by trying to devise an information process and architecture to tackle problems like the redesign of the hospital bed [13: p.51]. To the end of his life, Lansdown hoped to see a 'Designer's Information Environment' [47: p.23] which would allow designers to use a computer exploratively while supporting them with all the information they needed in a readily usable form.

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