10
Metamorphosis of the Artificial

Designing the future through tentative links between complex systems science, second-order cybernetics and 4D design

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1 Introduction

This chapter introduces the author's perspective in respect to his investigation into embracing the science of complex systems from an Art and Design background. It covers a wide context and approaches the creation of artefacts through the concept of '4D design'. The focus of the chapter is on the design of the relationships between 'everyday objects', people, and their environment involving a plethora of 'static' and 'dynamic' characteristics. Particular attention is paid to aspects of the performance arts by embracing 'movement' as an important element in the process of design and conceptualisation of consumer products and built environments.

The chapter starts with a brief outline of complexity theory to set the scene. This is followed by an outline of the notion '4D design' combined with a performance arts perspective – 'applied choreography' – and Second Order Cybernetics (C2), which has some resonance with both the notions of the 'science of complex systems' and 4D design. The notion of 'soft innovation' is introduced concerning non-functional product characteristics related to aesthetic appeal. The chapter concludes with some reflection and provocations as to future related possibilities for innovation in everyday products, services and systems in the built environment. This is intended to be a catalyst for further thought and modest inspiration.

The author acknowledges that the topics covered are rather *ad hoc*, and that traditional scientific approaches to discourse are not strictly followed – not least in respect of the fact that methods for research differ between disciplines, and that 'design enquiry' can be different from 'scientific enquiry'. There is less of providing rational systemic information on-a-plate with the hope that all recipients will get a homogenous message (this is touched upon later). Instead the chapter recognises the value of 'ambiguity', which can increase the chance of unique connections 'emerging' by individual perception.

2 Complex systems science (CSS)

'Complex systems' is a general term used to describe systems that are diverse and made up of multiple interdependent elements. Many agree that complexity can emerge from the interaction of autonomous agents – especially when agents are people (Bourgine and Johnson 2007). There are numerous reasons as to why a system might be considered complex, including having one or more of the following characteristics (Johnson 2007):

- many heterogeneous parts
- complicated transition laws
- unexpected or unpredictable emergence
- path-dependent dynamics
- network connectivities and multiple subsystem dependencies
- dynamics emerge from interactions of autonomous agents
- self-organisation into new structures and patterns of behaviour
- non-equilibrium and far-from-equilibrium dynamics
- adaptation to changing environments
- co-evolving subsystems
- ill-defined boundaries
- multilevel dynamics

There are numerous definitions of 'complexity', and any one of these characteristics can make systems appear complex (Johnson 2006b; Horgan 1995; Edmonds 1999). Generally the use of 'complexity science' methods involves managing or controlling a system of elements so that their interaction as a whole moves towards 'desirable' future paths or states, and away from undesirable ones. The 'complex systems science' as a whole encompasses notions that can be applied to both the design of the built environment and human situations.

Like 'complexity', the definition of 'design activity' is hard to pin down, as it encompasses multifarious activities and perspectives. At one extreme there is 'evidence-based design' (EBD) with a rigorous research element, and at the other there is 'creativity-based design' (CBD) which uses the rich ambiguity of talented artistic search. The definition of Herbert Simon (1969) for design is useful here as a basis.

> Design is the transformation of existing conditions into preferred ones.
>
> (Simon 1969: 55)

3 4D design

The notion of 'transformation', along with 'metamorphosis', is at the core of the concepts presented here, with the idea that there are designs designed that are not currently considered as being designs in a 'professional context', and it is timely to consider *new ways* for creating the artificial. A position taken is that one way can be characterised, in part if not in whole, by the definition of '4D design' along with ideas of cybernetics and complexity science. It is suggested that readers view the website www.4d-dynamics.net in conjunction with reading this section. Although the definition is close to the sciences of complex systems science and cybernetics, 4D design has a cultural and aesthetic context and a more intuitive way of looking at the artificial world involving people.

> A 4D Design is the dynamic form resulting from the design of the behaviour of artefacts and people in relation to each other and their environment.
>
> (Robertson 1995)

4D design focuses upon designing 'cultural expression' within dynamic situations of the everyday 'designed' world in the field of Art and Design along with 'utility'. The main characteristics of 4D design are depicted in Figure 10.1. This is a diagrammatic conception that crucially shows the relationship of the performance arts to functional actions of people and dynamic technologies fundamental to it. The diagram has four basic domains of knowledge; two cover the dynamics of intangible media and tangible artefacts – multimedia technology and robotics; the other two deal with the dynamics of people, first, within functional work – 'ergonomics' – and, second, 'play', focusing on the performance arts involving dynamic cultural expression and meaning. In Figure 10.1 there are also subset domains shown, and these are: the relatively new discipline of 'interaction design', focusing on the usefulness of digital technological objects; 'interface design', focusing on the usefulness of digital informational media, e.g. screens

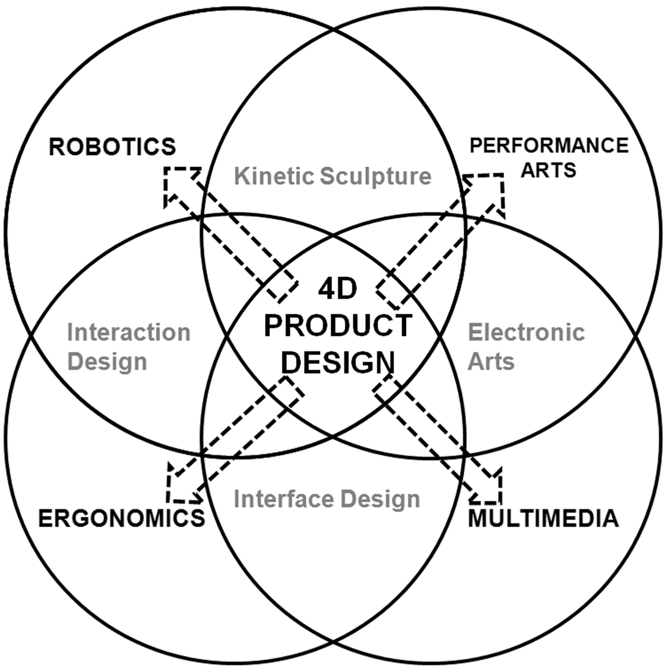

Figure 10.1
4D design diagram – Alec Robertson (1995)

and surfaces; the 'electronic arts', which deal with expression through intangible digital media including art installations; and 'kinetic sculpture', which focuses on dynamic expression of material art objects.

The arrows recently added through the '4D design' core of the diagram highlight that it can mainly involve the design of relationships between 'the artificial' in the form of digital multimedia and robotics technologies, or mainly involve 'people', encompassing both the utilitarian perspective of 'ergonomics' and the more playful 'performance arts'. In other words, 4D designs can result in artefacts alone acting in relationship to each other, such as robots dancing interactively with digital graphics on screens (although a human observer is assumed to be present), or mainly people acting in relationship to each other, such as the elegant performance of an up-market restaurant waiter with a customer (without much technology such as a portable credit card reader. The professional context of service design is a creative challenge (Robertson 1994).

The conception of 4D design here is limited to that of the 'everyday' contribution of Art and Design designers to the artificial world, where people are central, and where culturally rich dynamics are a main characteristic. It generally excludes systems where people are not present, such as the dynamics within an engine, and creations of the 'pure or fine arts' with no utilitarian purpose. In this context we can ask the question: What might the notion of 4D design with the science of complex systems contribute to artefacts and the actions of people in the 'everyday' built environment?

To help answer this question, the author designed and organised three symposia in close collaboration with the research cluster 'ECiD – Embracing Complexity in Design' (Johnson 2006b). (The author considers these events to be one type of 4D design.) Two events designed had the title 'More is More' (Robertson 2005, 2008). The first focused generally on the 'nature of design', and the latter on complexity in relation to the design of robotic devices with performative characteristics. The third event was called 'Magic in Complexity' (Robertson 2007) and focused upon multimedia game design from an arts perspective tentatively associated with 'complexity'. These events demonstrated that the field of Art and Design and the science of complex systems have shared interests to explore, with their complementary inherent differences, such as the use of different terminology and languages, personalities of 'different' people engaged, and idiosyncratic group behaviour that emerges from interdisciplinary work (Everitt and Robertson 2007).

The first symposium, 'More is More: Embracing Complexity in Design' (Robertson 2005), held on 16–17 December 2005, was the finale event of phase 1 of the 'Embracing Complexity in Design' research cluster; part of the UK AHRC and EPSRC research initiative 'Designing for the 21st Century'. The aim was to stimulate intellectual academic exchange, celebrate and disseminate the work of the ECiD cluster. It brought some members of the complexity science community together with several engaged in the Art and Design community. Figure 10.2 shows john chris jones giving the Symposium Dinner Address.

The second symposium, 'Magic in Complexity: Embracing the 4D Design-Arts' (Robertson 2007), took place on 23 February 2007. This event was part of the

Figure 10.2 'More is More' Event in the RCA Senior Common Room. Photo by Ismail Saray of ARTZONE, 2005

second phase of the 'Embracing Complexity in Design' research cluster – ECiD2. It comprised a symposium with keynote presentations, a networking soirée, and included Stimulus Talks and Serendipity Syndicate workshops, with interdisciplinary participation. The Serendipity Syndicates addressed five questions aimed to assist the ECiD2 research being done:

S1. How can the methods of complexity science assist digital games designers?
S2. How can design of 'play' in digital games inform research into complex systems?
S3. How can we create complex adaptive educational digital games?
S4. How can complexity help us to understand the enabling conditions of creativity and design?
S5. How can complexity theory be applied to the design arts in general?

Multimedia proceedings of this event are available via www.4d-dynamics.net

The five basic points below summarise the deliberations of the Serendipity Syndicates:

Summary Point 1: Understanding complexity theory helps designers to open up the games so that players can take part in the emergent design. Games design and complexity science is a fruitful area to explore further.
Summary Point 2: Play and Game design theory characteristics may be applied to Complexity theory characteristics.
Summary Point 3: Educational games can provide very simple visual solutions to very complex systems. This opens up the space for learners as they can appreciate small stimulates while grasping that they originate from a more complex whole.

Summary Point 4: In creative work involving complex systems, success is not readily measurable in the short term. This may be fundamentally at odds with the realities of complex systems.
Summary Point 5: Artistic work often explores how behaviours of systems emerge. Emergence can manifest itself both as part of the artistic process and as an outcome – look at artworks as systems rather than dissecting them into their constituent parts.

The third symposium, 'More is More 2: 4D Product Design for the Everyday' (Robertson 2008), had a basic tenet that new creative industries may well appear in the twenty-first century that we have yet to conceive of, and it is important to explore *avant garde* ideas for these related to 'complexity', robotics and the performance arts. This event included an afternoon symposium followed by an evening of public DIALOGUE in the Dana Centre of the Science Museum, London. '4D objects' were available to stimulate emergence of ideas for future design practice and research. Encouraging reflection by experts and the general public alike upon our relationship to 'dynamic objects' for 'real world' application as 'delightful' and 'useful' products, systems and services was the purpose of the day, along with dissemination of some interesting research being done. Figure 10.3 depicts a set of screen shots from its video proceedings to give a flavour of this event.

In summary, the events had a prime role of 'dissemination of research', with experimental multimedia online proceedings assisting this to a wide audience. The second event, 'Magic in Complexity', resulted in a special issue of a journal (Goodman *et al.* 2007); and the third, 'More is More 2', enabled dissemination of high-level design research directly to the general public, amongst other benefits. It was established that artists

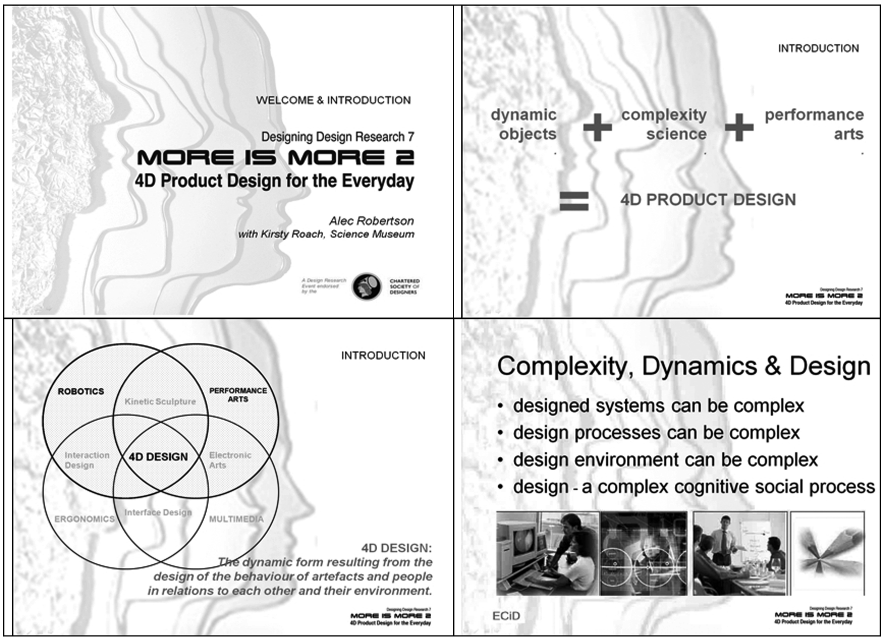

Figure 10.3(*a*) Sample video stills from 'More is More 2: 4D Product Design for the Everyday'

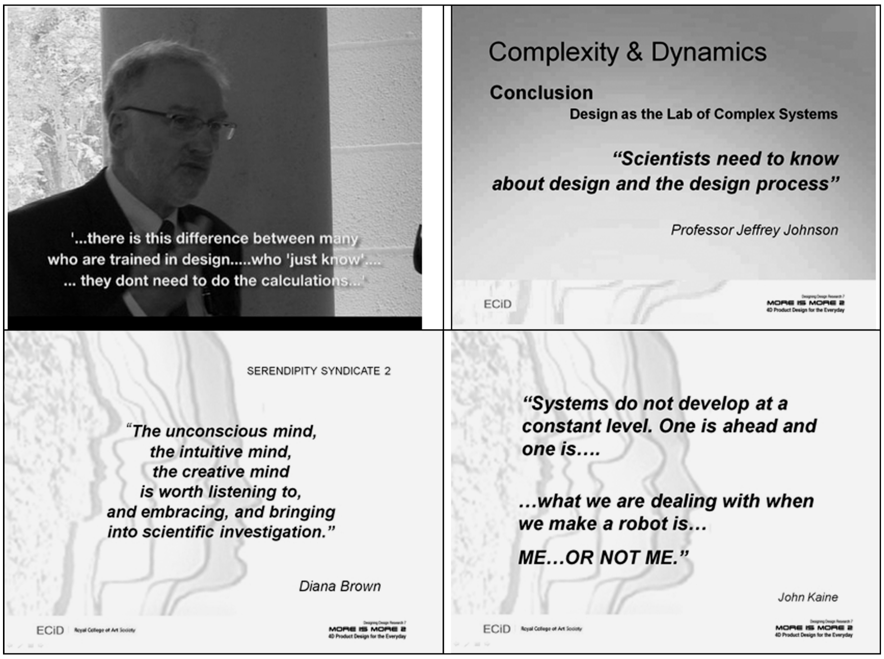

Figure 10.3(*b*) Sample video stills from 'More is More 2: 4D Product Design for the Everyday'

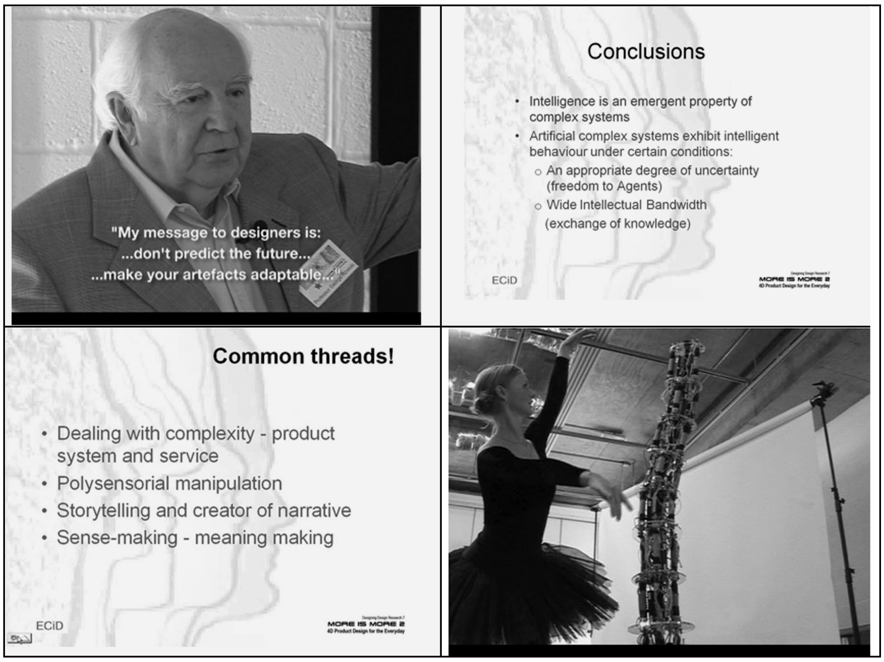

Figure 10.3(*c*) Sample video stills from 'More is More 2: 4D Product Design for the Everyday'

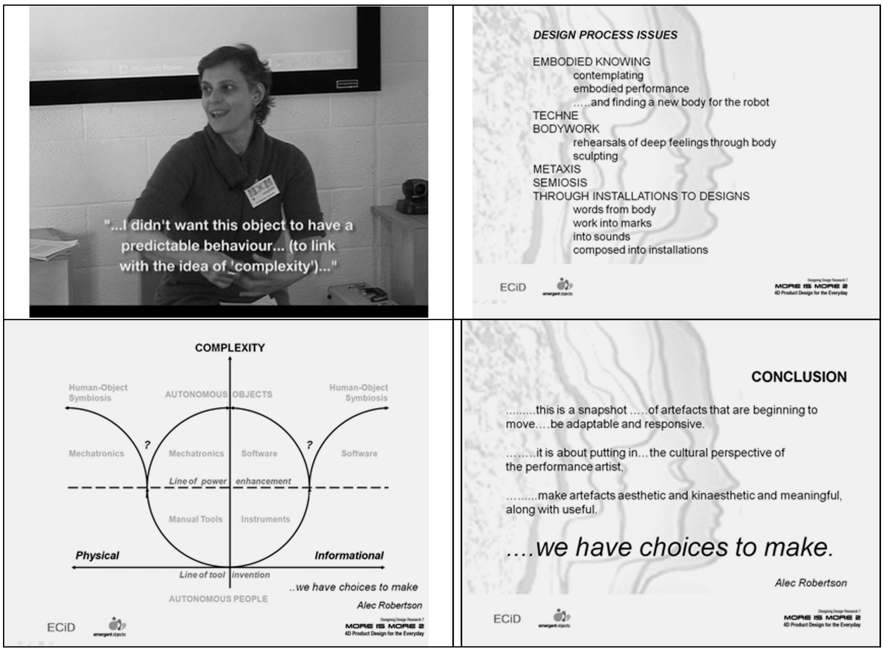

Figure 10.3(*d*) Sample video stills from 'More is More 2: 4D Product Design for the Everyday'

and designers can cooperate with engineers and complexity scientists and have shared interests. There was a recognition that designers are often capable of intuitively grasping 'complexity' when they design within their specialism, and Art and Design could offer much to this new frontier of 'complex artefacts' with its 'ways of visualisation' and 'ways of knowing'. Lessons were learned for organising future interdisciplinary events to maximise outcomes of such ventures, particularly for the effective 'capture of ideas' on the day. Participants on the day made connections on their own, and the author as both convenor and a participant has been able to make tentative connections generally in relation to his own viewpoint, and some are embodied in this chapter. Visitors to the On-line Proceedings at http://www.4d-dynamics.net/ddr7/ will, it is anticipated, make their own creative connections, too, as 'autonomous agents' in the spirit of the science of complex systems.

4 4D product design

So how can concepts of 4D design with complex systems science enable the creation of new kinds of 'artefacts' for the 'everyday – 4D products'? At the event 'More is More 2', 4D product design for the everyday is defined as:

4D Product Design = Dynamic objects + complexity science + performance arts
Robertson (2008)

Let us consider the notion of 'dynamic form' through the term of 'applied choreography'. This is a term proposed by the author as an attempt to encourage transdisciplinary work between the fields of 'design' and the 'performance arts' (Robertson and Woudhuysen 2001). The concept encourages application of useful choreographic knowledge to everyday life situations (outside theatre stages and without trained dancers). Sophia Lycouris has outlined a relevant theory in relation to architecture where 'space' is caused by the interrelationship between body, movement and space, and the act of design becomes the shaping not of buildings, but of space conceived in relation to a moving point of reference (in Robertson *et al*. 2007). She adds that interdisciplinary articulations have supported the development of conceptual frameworks for an understanding of architecture as a discipline which can accommodate change and instability, as well as material and conceptual flexibility (Brayer and Simonot 2002), and points out that various 'professional' architects, such as Lars Spuybroek and Peter Eisenman, have challenged the perception of architectural space, too. The advantage of creating architectural space with an integrated understanding of its dynamic potential, according to Lycouris, is that such space can increase the corporeal responses of the viewers or users, in the sense that as they move through the building they perceive space more intensely as a result of the generation of multiple physical sensations. The conclusion drawn is that expanding our understandings of choreography as a compositional method generally means that new design possibilities can arise. With the support of architectural theory that recognises the relevance of movement for users' experience of architectural space, such as that introduced by Sophia Lycouris above, new conceptual architectural possibilities can open up. An understanding of space as a dynamic entity (which includes objects and animate agents or people) presents a challenge to the static character of architectural design conceptions and manifestations generally.

4D design helps to make conceivable the integrated choreographic understanding of all manifestations of movement in a given physical space beyond 3D iconic form. In the architecture of public spaces, the concept of 4D design brings together physical objects, media and the activity of people within space, and can thus engender a dynamic multisensory expression of culture. With the tentative linking of choreography, architecture and complex systems through 4D design, and an emphasis on dynamics, interaction and relationships between the behaviour of artefacts and their users, it should be possible to expand the potential for collaborative ventures between disciplines. Some design research speculation on radical new design possibilities is left to later in this chapter.

5 C2 cybernetics

This brings us to the topic of 'cybernetics', which has some resonance with the science of complex systems and 4D design. A general view of this concept is given by Ashby (1956). More recently, the idea of second-order cybernetics, or C2, has been seen as increasingly pertinent. Ranulph Glanville highlights that an early cybernetics scholar, Heinz von Foerster, pointed out the absurdity of the traditional denial of 'the observer' in science, where there is a fictional creature through which knowledge is somehow immaculately generated (Glanville 2008). Foerster (1974) distinguished two types of cybernetics:

> First order cybernetics is the cybernetics of observed systems.
> Second order cybernetics is the cybernetics of observing systems.

Glanville depicts the difference between the two in the following way. 'First order cybernetics (C1) is concerned with circular systems, or systems of circular causality. In C2, we accept that the observer is "touched" (and touches) what goes on and there is circularity: the observed system is circular, but the observing system is also circular.'

To illustrate this, Glanville uses the classic example of a switch mounted on the wall to control a furnace which delivers heat to a room. He asks: 'What controls the switch, causing it to turn the furnace on and off?' Temperature is the answer provided, which in turn depends on the heat provided by the furnace. So it is the furnace that controls the switch, and each controls the other in fact. Glanville adds that the only reason why we call the switch the controller rather than the furnace derives from considerations of energy: the idea of a small amount of energy controlling a larger amount, which in turn entails a concept of 'amplification'. Cybernetics is primarily interested in flows of information rather than control; of physical energy, and the latter can be referred to as 'mechanisation' in the context of machines.

Another related C2 concept stressed by Glanville as important is 'conversation'. The view of communication based in Claude Shannon's 'Mathematical Theory of Communication' is that of 'passing coded messages accurately down channels with capacity to contain them' (Shannon 1948). Glanville highlights that, in C2, communication is not via coded messages that all people will receive as the same, but by conversational construction of pluralistic meanings that result. The sender may hope that all people receive a message well enough to get what s/he means as an aggregate. So, in C2, each communicator constructs their own meanings from the messages they pick up, which may well be different. In 'complexity science' terms, instead of considering one agent as being responsible for what happens, all agents control and maintain a system together as an aggregate of their individual presences, where each will perceive the situation differently.

For Glanville, 'conversation' is real 'interaction', and current use of the word 'interactivity' in computer and design fields is usually misconceived. So a challenge for designers is to consider the use of a product not as an action by a person on a machine or vice versa, but as a property of a system existing between them where each affects and is affected by the other. Importantly the system will involve 'movement' of some kind when observed externally: it will be 'dynamic'. In a circular system, in the sense of a cybernetic conversation, the '4D design' does not come from any one participant, but from the 'emergent property' of all participants acting together. It is shared and cannot be divided into the contribution of one or the other element, and each will perceive the situation differently.

The notions of 'interaction' and 'interface' design from the viewpoint of 4D design need expanding in this light. Paul Martin (1995) describes this idea of 'the space within' in the context of designing interiors of buildings from a 4D design perspective, where both the objects and the immaterial dynamics within the spaces are designs. Glanville calls this the 'inter-space', and adds: 'The challenge is to create this inter-space that will support conversational interaction' (Glanville 2008). Consideration of the participant in the 'inter-space' also involves use of a subject as its own subject (self-reference), as well as being one of multiple autonomous participants or 'agents'. C2 is a powerful concept and important for designing, especially where imagination and creativity are allowed to flourish. In a 'complex situation', 4D designing results in dynamic form both of the agents, and importantly, within 'the space between' them, through the creation of an unpredictable holistic 'emergent dynamic form' experienced by participants and observers. For example, imagine a person dancing with a robot where they are both in conversation through movement. Numerous luminous elastic bands are tied between them. Turn the lights off and you will see the dynamic form only 'in the space between'. The elastic bands are a metaphor for meaningful dynamic connections between them – a 4D design.

6 4D design innovation

Speculating about the possibilities of the conjunction between complexity science, 4D designing and C2 cybernetics for innovation requires brief consideration of changing ideas within the notion of 'innovation' itself. Definitions of concepts related to innovative activity, research and development (R&D) are found respectively in the Oslo and Frascati manuals (OECD 2002; OECD 2006). These are highlighted by Paul Stoneman, who adds to 'product innovation', 'process innovation' and 'marketing innovation' the concept of 'soft innovation' (Stoneman 2007).

> A soft innovation is defined as changes in either goods or services that primarily impact upon sensory perception and aesthetic rather than functional appeal . . . where a soft innovation may have different looks, touch, smell, aural patterns and will differently address personal preferences as to these.
>
> Stoneman (2007)

This definition concerns the value of 'aesthetics' in a wide range of industrial sectors from consumer products to architectural services outlined in Higgs *et al.* (2008). Aesthetic innovation is a subject of some research in terms of commerce for manufactured 3D product designs (see Marzal and Esparza 2007; Tether 2006). Paul Stoneman, with his business perspective, highlights that the measurement and judging of commercial aesthetic significance are poorly developed, although he adds that approaches that have been suggested might be 'influence upon others', 'the number of imitators', or the 'extent of copying'. At present, valuation of 'aesthetics' in the first instance is usually left to the intuition of experts who are acknowledged to be skilled judges in a field – not least, for example, Art and Design educated designers, and architects etc.

However, 'kinaesthetics' and other 'performative' qualities of 4D designs complicate assessment of aesthetic value in innovations. The perspective of 4D designing is a radical departure from the norm of 2D and 3D designing within the field of Art and Design, and it is a way of designing some sorts of activity that are not included in the categories of contemporary design education or 'professional design' (Robertson 1995). As a result, many such 'products' are not designed well. The 2D surfaces of many contemporary electronic consumer product interfaces, such as mobile phones, that largely comprise flat graphics are often too small to see or touch by many users. The 3D spatial design in many electronic goods is increasingly just to 'contain' the electronics as well, often in the form of anonymous 'black boxes', where possibilities for enabling 3D form to 'tell' users what to do through creating communicative 'affordances' (Krippendorff 2006) is there, but not exploited to full potential. This leads to the topic of dynamic 'affordances' possible with 4D design in consumer electronic products, which is, however, beyond the scope of this chapter.

So where are we going with all this understanding of 4D design with 'soft innovation', and its cousins C2 cybernetics and complex systems science?

7 Some speculation

The notion of 'metamorphosis' is at the core of possible innovation in 'the artificial'. At a basic level of complexity, 'modularity' is one physical way to encourage metamorphosis; as seen in the plug-in form of desktop computers with various levels of module sophistication, but also present in many other artefacts from Lego toys to buildings. With 'software' now embodied in many artefacts, including buildings, another way is by movement of the physical elements as articulated forms using performative robotics (McKinney *et al.* 2008). There is some speculation below on what innovation might result from using these notions to give more complicated levels of 'complexity' in 4D designs.

In the early 1990s there were notions of 'the intelligent building', cybercontrol systems (in contrast to automatic), 'archionics engineering' (analogous to avionics for aircraft) and 'kinematic buildings' (in contrast to static) (Robertson 1993). It was advocated that a building could be as beautifully responsive as a plant when changing within its environment and, with gentle articulation of its components, as graceful as a ballet dancer. Later questions were posed like 'Is the 'automatic door' which opens as one approaches the beginning of buildings dancing with people? 'Can we look forward to buildings and a built environment that responds kinaesthetically with each other as well as efficiently, with subtle performances of buildings in our cities?' (Robertson

2007). Examples of such 'kinematic architecture', where a building incorporates motion through use of dynamic technologies, are beginning to appear (see Robertson 2008 i). This way the built environment may become more amenable and less controlling. Likewise there are indications that consumer products are becoming more responsive (see Robertson 2008 ii). With the 4D design perspective on dynamics, we can encourage dynamic architectural expression within the whole public experience; designs involving choreographic expression within articulated buildings, consumer products, media displays, traffic and people. What could be possible with notions of complex systems science, and specifically the interrelationships of 'autonomous agents' within cityscapes? Concepts of complex systems such as 'swarming' and flocking are useful. One impact may be on the 4D design of 'traffic' of people and vehicles.

Movement of commuters on pathways could create a kinaesthetic spectacle, as could traffic flow through urban roads. 'Intelligent' traffic signals embodying choreographic ideas could encourage vehicles to interact during acceleration and braking, creating delightful movement for participants and observers alike, as well as efficient traffic flow. On the motorways there is the phenomenon of 'herds' of vehicles, and if cars incorporated 'social' software they could communicate with each other with courtesy using smart materials and technologies, as well as adjusting their drive to increase safety for themselves. Imagine a particular make of car, such as an Audi, communicating with other Audi cars by colour changes, thus operating like the driver ritual of flashing indicators to respect good reciprocal driving behaviour. Similarly, robotic traffic lights could sense your car approaching and wave you though a junction if no car is waiting with a pleasant comment through the radio sound system.

In the high-street fashion boutiques, smart fabrics for *haute couture* clothes could flirt by being aware of the wearer's physiological responses through sensing their environment. Dynamic elements embedded in the fabrics could create a greeting display, and even be like the flamboyant peacock displaying his feathers (see Robertson 2008 iii). On the farms and in factories it may well be effective to have 'colonies' of machines (Rzevski 2008) working in the fields and production lines that move with performative qualities in a ritual dance of their own design while working.

We can ask what might be in a design 'research-exhibition' (Robertson 2006) of 4D designs today. First, it may well be more like going to the opera as it would be 'poly-sensorial', and 'performative', and possibly 'collaborative'. In addition it will involve 'circularity', 'sharing experiences', 'mutuality', 'reciprocity' (Glanville), 'adaptation' (Rzevski), 'semiosis' and 'habitus' (McKinney *et al.* 2008). Perhaps the above has enabled 'emergence' of ideas for such a research-exhibition or research-opera in you as a reader.

It could be asked: So what? Why do all this? The answer is the same as the answer to questions like 'Why have magnificent 3D architecture and interiors rather than everyone living in sheds' and 'Why have *haute couture* 3D garments and shoes, rather than all wearing uniform overalls and boots'. The issue is simply to transform existing conditions into preferred ones and create a 'delightful' artificial environment for living in.

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