> DEST outcomes value creative work as lesser than research output, and it's hard not to be caught up in this, as the pressure is on to remain 'research active' and produce articles that appear in refereed journals. My poetry in literary journals, anthologies and book form just isn't seen as significant in comparison to those refereed articles.

Overall, the impression the answers gave was that the respondees were searching for ways of articulating the relationship between creative practice and research, and did not necessarily feel that any one way of speaking about that relationship was adequate. Similarly, there did not seem to be a very strong pre-existing vocabulary or conceptual framework into which they could easily fit their thoughts about the issues. Nevertheless, there was a strong convergence that research and creative practice overlapped, and it was notable that many participants claimed to be active in independent research.

OUR MODEL: THE ITERATIVE CYCLIC WEB

Figure 1.1 illustrates our model of creative and research processes; it accommodates practice-led research and research-led practice, creative work and basic research. The structure of the model combines a cycle and several sub-cycles (demonstrated by the larger circle and smaller ovoids) with a web (the criss-cross, branching lines across the circle) created by many points of entry and transition within the cycle. One intention of Figure 1.1 is to suggest how a creative or research process may start at any point on the large cycle illustrated and move, spider-like, to any other. Very important in the model, with regard to the sub-cycles, is the concept of iteration, which is fundamental to both creative and research processes. To iterate a process is to repeat it several times (though probably with some variation) before proceeding, setting up a cycle: start–end–start. The creator must chose between the alternative results created by the iteration, focusing on some and leaving others behind (temporarily or permanently). In a research phase, this can be viewed as a selection based on empirical data or an analytical/theoretical fit; in a practice phase the choice might be aesthetic, technical or ideological, or somewhat random. Iteration is particularly relevant to the sub-cycles but also to the larger cycle.

The outer circle of the diagram consists of various stages in the cycle of practice-led research and research-led practice, and the smaller circles indicate the way in which any stage in the process involves iteration. The right-hand side of the circle is more concerned with practice-led research, the left-hand side with research-led practice, and it is possible to traverse the cycle clockwise or anti-clockwise as well as to pass transversely. Moving clockwise, a creative arts practitioner may start at the top middle with an idea or play with materials

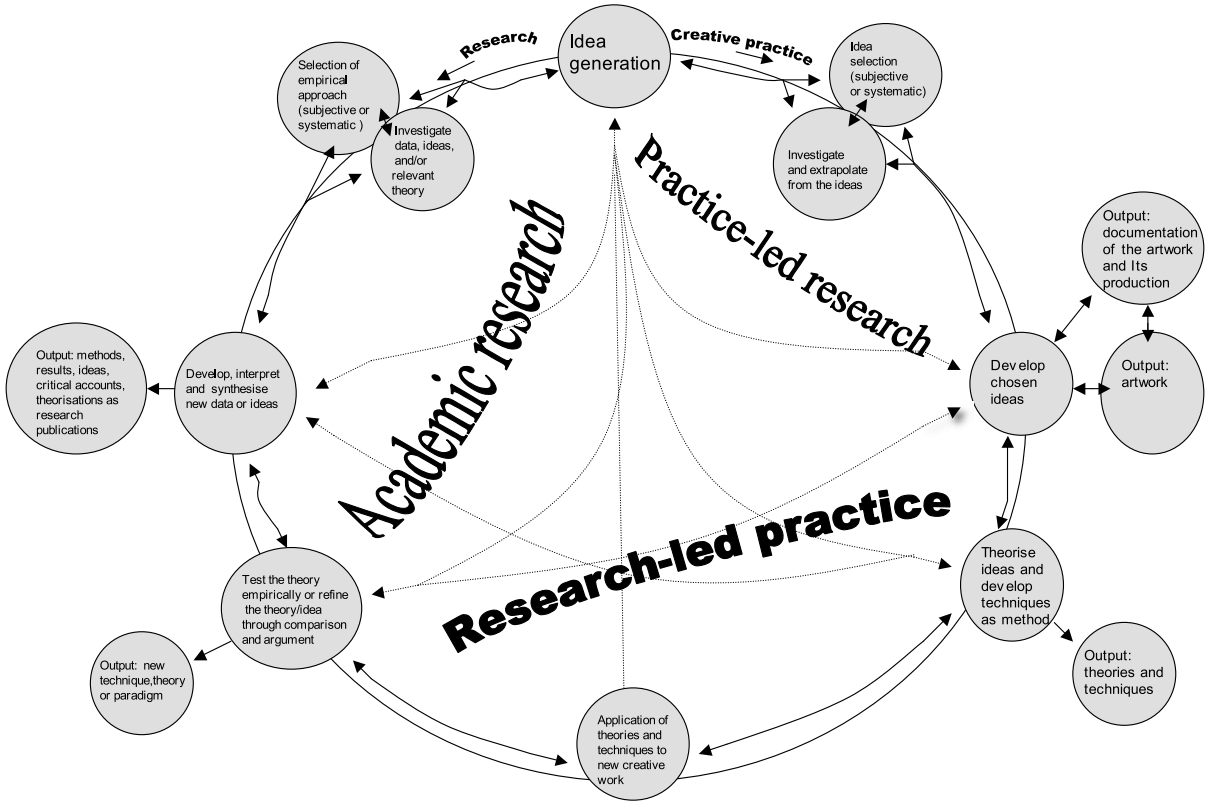

Figure 1.1 A model of creative arts and research processes: the iterative cyclic web of practice-led research and research-led practice.

to generate ideas. This process is followed by the selection of ideas (which may be sounds, images, formations of words) which are pursued through investigation or research. These ideas are then developed and released through publication or other public outlets. If we advance round the circle clockwise we note that publication may be followed by formulation and theorisation of the ideas, processes and techniques which have developed through the creation of the published artwork. These formulations and theorisations may, in turn, also be published and/or applied to the generation of future creative works. However, at every stage of the cycle it is possible to go back to previous stages. So, for example, selection of an idea might instigate a return to the idea/generation stage. Similarly, the investigation/research stage might also result in a revisiting of the generation of ideas and so on. The cycle structure is combined with a web-like structure to demonstrate how it is also possible to jump from one point in the circle to any other. Publication, for example, might result in a reversion to the ideas stage.

Starting at 'idea generation' and moving anti-clockwise is a representation of the research process found in both science and the humanities. If we begin with idea generation and follow the circle anti-clockwise, we move through a series of processes which counterbalance those on the right-hand side of the circle but are more geared towards academic research. The sub-circles refer to different kinds of research from more scientific and empirical approaches to more theoretical or historical approaches. These emphases are, of course, themselves fluid: for example, designing experiments has been thought central to science for a long time, but the extent of empirical work in the humanities is now increasing dramatically. If we pursue the circle round, idea generation leads to experiments, gathering of data and/or analysis of theory or criticism. This may be followed by the development or synthesis of material and can, in turn, lead to the testing of the theory, either empirically or by argument and comparison, with outputs at a number of possible stages.

It is now obvious that this is a reversible cycle and that it is possible to move round it fully in either direction. So theories developed through creative practice on the right-hand side of the cycle might be refined and generalised as part of the research process at the left-hand cycle side, and the web-like structure allows for movement across to the more basic research at any time.

The web-like aspect of the model clearly suggests connections with the Deleuzian rhizome in which any point can be linked to any other and there are 'multiple entryways and exits' (Deleuze and Guattari 1987: 21). For Deleuze and Guattari, 'A rhizome has no beginning or end; it is always in the middle, between things, interbeing, *intermezzo*' (Deleuze and Guattari 1987: 25). Such analogies to the Deleuzian rhizome have been made before in the area of practice as research, for example by Irwin and Springgay (in Cahnmann-Taylor and Siegesmund 2008). They apply the notion of the rhizome to arts-based

research in education through the movement of 'a/r/tography' which 'as practice-based research is situated in the in-between, where theory-as-practice-as-process-as-complication intentionally unsettles perception and knowing through living enquiry' (p. 107). For Irwin and Springgay the rhizome is 'an interstitial space, open and vulnerable where meanings and understandings are interrogated and ruptured' (p. 106). They continue by arguing for its relevance to their own enterprise, 'building on the concept of the rhizome, a/r/tography radically transforms the idea of theory as an abstract system distinct and separate from practice' (p. 106). Strongly influenced by feminist and poststructuralist theory, a/r/tography is concerned with 'relational inquiry, relational aesthetics and relational learning' (p. 115). While these formulations of a/r/tography are elusive, the element of continual and reciprocal transference they suggest is coherent with our model.

As mentioned, Figure 1.1 illustrates how each stage of the large cycle itself usually involves iterations (symbolised by the smaller cycles straddling the main circular cycle) and selections from those iterations. In the process of selection the researcher/practitioner decides which are the best or most useful realisations derived from the task, and discards or temporarily puts to one side the others. Here each iterative step is an example of the operation of a selective pressure, somewhat like those that over aeons determine biological evolution and the success of genes and organisms. Biological processes hinge on the survival of the fittest, but fitness depends on the environment, so not all impressive species survive. Artistic selection processes are likely to be even more arbitrary, and there may be many fine specimens amongst the practitioner's rejects. This occurs because practitioners are making these decisions in relation to the specific artworks they are shaping (what would be suitable for one may not be appropriate for another), or because they might miss a good idea at an early stage of the process where its relevance or potential is not apparent. In addition, although we might be tempted to think of these choices as individually motivated, they are made in response to broader social and artistic forces. So the selection process is more cultural than biological and analogous to the activity of memes – ideas, theories or artefacts which evolve through mutation and competition and are suggested by Richard Dawkins to be the cultural equivalent of genes though over somewhat shorter lengths of time. Memes are discussed in Chapter 4 by McKechnie and Stevens; Estelle Barrett also suggests that the critical exegesis is a kind of meme because it 'may be viewed both as a replication or re-versioning of the completed artistic work' (Barrett 2007: 160).

Another type of selection process is fundamental in A-life (Artificial life) artworks, such as those created by Jon McCormack, which involve silicon-based (computational) organismal systems (McCormack 2003). Here selection is partly determined by the artist but then becomes built into the system.

In fact selective processes are at the core of most models of creativity, from the Geneplore model which characterises the creative process as generate–explore–select–generate, to the 'flow' model of Csikszentmihalyi (1997). But selection is also, as our model shows, relevant to research processes, where choices will occur along the continuum from arbitrary to exact, though usually with more emphasis on precision and contextual relevance than is the case with artistic choices.

Fundamental to our model are at least two different ways of working which are to be found in both creative practice and research: a process-driven one, and a goal-oriented one. To be process-driven is to have no particular starting point in mind and no pre-conceived end. Such an approach can be directed towards emergence, that is the generation of ideas which were unforeseen at the beginning of the project. To be goal-orientated is to have start and end points – usually consisting of an initial plan and a clear idea of an ultimate objective or target outcome. In Figure 1.1 these two different mindsets are signalled at various points, for example the initial idea generation can be one of surrender to the process or one of setting goals, while the ideas selection stage can be subjective (more process-orientated) or systematic (more goal-orientated). However, these two ways of working are by no means entirely separate from each other and often interact, as the model implies. For example, while the process-driven approach obviously lends itself to emergence, in fact at any moment an emergent idea may lead the way to more goal-oriented research. Similarly, a plan is always open to transformation as long as it is regarded flexibly.

The process-driven approach is usually thought to be more common amongst creative practitioners than researchers and almost certainly is, but many practitioners oscillate between process and goal, and may sometimes have an initial plan and/or some eventual endpoint in mind, however inexplicit it may be. Similarly, although research workers in both the humanities and the sciences usually have clear goals, engaging with processes along the way which allow for emergence, and permitting the project to shift in relation to them, is quite common and is often the secret of success. In a pleasingly hybrid way, the human genome project was one with a clear objective (defining the sequence of the DNA constituting the human genome) but also emergent outcomes (defining new and unexpected genes as well as acquiring better understanding of the function of metabolic pathways and the mechanisms of some diseases).

Implicit in Figure 1.1 is also the idea that the large cycle might represent not just the work of one person but that of a collaborative group with distributed expertises. Thus the creative practitioner might develop research skills but at the same time collaborate with a researcher who through engagement in the project takes an enhanced interest in more emergent and less preconceived outcomes. It is obvious that the creative, intellectual and financial environment

in which such collaboration and cyclic reciprocation is most feasible is that of higher education. Within creative arts companies it is more difficult, sometimes because of funding, though a few collaborative groups such as Canadian theatre director Robert LePage's Ex Machina manage to overcome this. Such companies may also have limited access to the complementary expertise of the scientist, the computer scientist or the research anthropologist. In higher education, such expertise would normally be part of the same community, and hence accessible. But the model's rhizomatic structure implies that interactions can take place between individuals from quite different communities and across cultures.

Figure 1.1 highlights some of the many points at which there might be transmissible outcomes. These outcomes can range from artworks to research papers, and might variously take the form of sound, text, image, video, artwork, numerical analysis of empirical data, argument, analysis or description. They might also include hybrid genres such as fictocriticism, itself a product of the rise of practice-led and research-led practices in the university. In the case of the numerical analysis of empirical data, or of argument, analysis or description, these outcomes might contribute to knowledge in humanities or science. If devolved from the process of making a creative work, they might embody understanding of the techniques which have been employed in creating an artwork and contribute to knowledge about the creative process. As we have suggested above, and as discussed elsewhere in the book, the transmission of technical possibilities through increased understanding of method and practice is potentially one of the most valuable outcomes of the rise of practice-led research.[4]

Our model also allows for the possibility that collaboration might not only be between scientists and artists or humanities researchers and artists, but equally between musicians, writers and visual artists, leading to the enhanced possibility of hybrid intermedia outputs. The mutual engagement on a project of practitioners with such a wide range of expertises and backgrounds is one of the most appealing aspects of creative arts collaboration, and potentially one of its most productive and valuable. The creative industries – the moving feast comprising the creative arts, film, TV, digital media and the Internet – in which such collaborations are particularly relevant, require such stimulus and synergy to thrive.

We hope that researcher-practitioners who read this book may use the model in Figure 1.1 to consider how much of the cycle they are actually engaging with, and to consider initiating projects from other entry points to it than those they normally engage. We also like to think it may encourage practitioners and researchers to participate in parts of the cycle in which they are currently absent. Several chapters of this book illustrate various ways in which essentially the complete outer cycle in Figure 1.1 can be fulfilled within projects: for example, Simon Biggs, and Andrew Brown and Andrew

Sorensen, with research in IT and creative arts practice in digital media; Sharon Bell with research in anthropology and creative practice in documentary film; Shirley McKechnie and Kate Stevens, and also Roger Dean, with repeating interactions between cognitive science and creative practice in dance and music respectively; and Hazel Smith and Anne Brewster with theorised humanities research combined with creative writing (in Hazel's case intermedia processes are also involved).

THE OUTPUTS: EVALUATION AND PROMOTION

Creative practitioners have sometimes argued that theorisation or documentation of the creative process risks subduing the creative fire or reducing the range of responses to their work. But such arguments reinforce the mystification of the creative artist and romantic ideas about the spontaneity of the creative process. Creative practitioners traditionally had an ideological investment in such mystification because it shored up the idea of the creative genius. However, there have been numerous examples of influential creative pioneers who laid out their ideas, strategies and critical positions through essays or manifestos: the composer Iannis Xenakis, the Surrealist painters and writers, and members of the writers' group Oulipo are good examples from sonic, visual and literary work. Similarly, there is also a wealth of work by contemporary writers and artists, such as the American language poets, which fuses practice and theory (see, for example, Bernstein 1999). All this suggests that there is no necessary contradiction between theorisation and creative practice, but rather that the combination can be valuable.

Currently there is an increasing trend towards documentation and self-description of creative work – as well as growing recognition of the self-critical awareness which is always a part of creating an artwork – whether or not it is externalised. Nevertheless, there may be certain aspects of the work that practitioners do not want to talk about, such as possible interpretations of it, and the role of the practitioner in these respects remains distinct from that of the critic.

The output points illustrated on our model must necessarily also be the points at which creative and research work is evaluated by others. In higher education such evaluation is necessary to demonstrate to governments that public subsidy is being usefully and valuably spent. But evaluation of outcomes is also requisite within the university to justify the apportioning of resources to creative practice and hopefully to increase the flow of resources to it. In the period in the early 1990s in Australia when creative work itself was argued to be 'equivalent' to research output, many university leaders lacked sympathy for the idea that creative work and research should be treated as equal. As

mentioned above, in Australia creative work has not up to now – apart from a brief period in the 1990s – impacted on the federal government Infrastructure Grants Scheme. However, the situation is different in the UK.

In the current higher education environment, if creative arts work itself can be presented as not only co-equal with research outcomes but also concomitant and interactive with them, it is more likely that support for it will be forthcoming. Thus the juxtaposition and interweaving of practice-led research and research-led practice is critical for the development of both endeavours, and especially for the future of creative arts in higher education.

How can the evaluation proceed? The general evaluation of a particular field by peer-researchers in science remains the most feasible approach, and garners the most acceptance among researchers, though it is far from precise, for example as judged by a detailed study of the peer-review process of the Australian Research Council (Marsh et al. 2008). Currently peer assessment of artistic work does occur at an informal level but hardly operates in a formalised way, so processes for peer review are at an embryonic stage in creative arts in many countries. But peer assessment similar to that common in academia could operate for initial assessment of artistic products; a peer group of practitioners could assess the outputs and methodologies for this have been developed and analysed. The 'consensual assessment technique' using domain experts, developed and applied by Amabile and colleagues, exemplifies this (Amabile 1996). We argue that such an approach is essential, even though peer-assessment in the arts is something of a minefield because of the highly subjective element in judging artistic work, and the tendency for ground-breaking work to be greeted with opprobrium rather than praise.

Peer review is anyway only the first stage in a process of evaluation because as long as the artwork is retained in circulation, recorded or documented, then – as with the scientific paper – a re-evaluation can take place later, and matters of public acceptance can play a more significant role. This public acceptance constitutes a major aspect of the 'impact' of artworks. Here we use impact to mean the degree to which the public engages with the artworks and appreciates them; we are not equating impact necessarily with cultural value, since a work which is esoteric can be extremely rich culturally but have a very limited public impact. In the short term, unfamiliarity – or perceptual fluency as it is known in cognitive research – can limit the impact of the work for some members of the public, but in the long term this issue of unfamiliarity can often be overcome: Harold Pinter's early plays were originally reviled by many, but he is now firmly established in the mainstream. Impact has always been notoriously difficult to assess but the degree to which the public interacts with artworks may become easier to measure through the Internet.

If the impact of an artwork arises out of the degree to which the public engages with it, then it is very different from the way that the public impact of science

operates. The main 'impact' of biomedical science, for example, is practical, whether it leads to useful pharmaceuticals or public health initiatives which reduce disease or enhance quality of life – and public use of published scientific articles is a minor factor in comparison with such practical impact. Of course sometimes artists may be able to engineer social and practical changes through their work, or may be able to liaise with scientists or engineers to further the public good. Rust, for example, discusses convincingly the way designers can work with scientists to considerable social and practical effect (Rust 2004).

Another measure of impact is the issue of long-term peer recognition and use. In the case of scientific research, citation analysis of research publications estimates the number of times other peer researchers have quoted the work of a particular researcher in their own publications and so indirectly how much the work has been used. Again the Internet, together with increased documentation of artists' processes, might eventually permit a similar assessment of peer usage in the creative arts, but this does not exist adequately yet.

As far as processes of evaluation are concerned, therefore, creative arts research could usefully borrow from the scientific model, though the criteria of assessment would need to be radically different. University leaders can no longer dismiss creative work from such consideration, and creative practitioners must be open to it. In fact their mutual participation in evaluative processes is both a necessary and desirable step towards the complete equality of creative arts with other intellectual endeavours within higher education.

One of the reasons that such equality is important is that those involved in higher education need to convince politicians of the importance of both the arts and other academic activities for the maintenance and development of our societies. Many artists are reluctant to couch any argument about the value of art in economic rather than socio-cultural terms, even though they appreciate that politicians tend mainly to be interested in finance. But creative industries are very large industries in developed and some developing countries, and there are considerable differences in the percentage of GDP they contribute between the UK, the USA and Australia. They often supply between 5 and 8 per cent of GDP, but have increased more dramatically in some countries (such as the UK) than others during the last decade. The scope remains for considerable further enhancement of the economic contribution which can be made by art, and one of the roles of higher education academics and creative practitioners is to try to ensure that this happens and that valuable artistic and socio-cultural outputs and impacts ensue, not just direct economic gains. Throsby and others have shown that, in the case of the visual arts, for example, the estimated financial impact of artistic work derives not so much from the sale of work but from other socio-economic factors (Throsby 2006). Quite probably the economic impacts of medical research have been so successfully argued that they are overestimated, while almost certainly those of the creative arts have been both

under-argued and underestimated. But politicians can potentially be engaged and energised by all of these kinds of argument and evidence. This is more likely to be achieved if methods of evaluation are demonstrated and equality of the potential significance of creative arts work, practice-led research and research-led practice is claimed, exploited and promoted.

THE CONTRIBUTORS: KEY ARGUMENTS

The authors in this book engage with a wide variety of arguments about practice-led research or research-led practice. In the opening chapter of Part 1, while focusing on practice-led research in the visual arts, Graeme Sullivan argues that 'artists themselves have the capacity to explore and explain complex theoretical issues that can have significance across broad areas of knowledge' and can make 'intuitive and intellectual leaps towards the creation of new knowledge': for Sullivan 'the artist intuitively adopts the dual roles of the researcher and the researched' in 'a reflexive process'. Consequently, he says, they should be aware of 'the necessity of communicating across fields of inquiry'. Sullivan continues the arguments raised above about the potential importance of practice-led research in universities, pointing to the desirability of 'research practices that are inherently discipline-centred in the arts and humanities'. For him practice-led research implements methodologies which move from the 'unknown to the known', rather than more traditional research methodologies which move from the 'known to the unknown'; he also emphasises processes of data 'creation' rather than 'collection'. Sullivan notes that the work may have outputs which are emergent, including some that are non-verbal – the concept of emergence appears throughout this volume. His chapter concludes with an illuminating discussion of a collaboration in which a New York 'exhibition space was conceived as a research site'.

Simon Biggs (Chapter 3) focuses on 'practice as research' in new media and its recurrent emphasis on 'development and/or application of emergent mediating tools and systems', resulting in its capacity to be highly divergent. In dedicating a section of his chapter to terminology, he points out that there are quite disparate views among practitioner-researchers as to what constitutes practice-led research, that many have not routinely distinguished research-led practice or do not wish to do so, and that there is clearly substantial instability and slippage in the larger discourse about practice and research at present. This is obviously relevant to our own objective of bringing these different axes (practice-led research, research-led practice) into clearer view and our wish to create, if possible, greater stabilisation of terminology. Biggs quotes the UK Research Assessment Exercise (RAE) definition of research which extends from the terminology 'knowledge' to what we might call the 'softer' terms

CHAPTER 7

Integrating Creative Practice and Research in the Digital Media Arts

Andrew R. Brown and Andrew Sorensen

INTRODUCTION

Research is often characterised as the search for new ideas and understanding. The language of this view privileges the cognitive and intellectual aspects of discovery. However, in the research process theoretical claims are usually evaluated in practice and, indeed, the observations and experiences of practical circumstances often lead to new research questions. This feedback loop between speculation and experimentation is fundamental to research in many disciplines, and is also appropriate for research in the creative arts. In this chapter we will examine how our creative desire for artistic expressivity results in interplay between actions and ideas that direct the development of techniques and approaches for our audio/visual live-coding activities.

There is a definitional hurdle that we believe needs to be exposed at the outset of discussions about practice-led research concerning the term 'research' itself. There is a general way in which research is a part of many activities. In this general way, research refers to the act of finding out about something and is involved in learning about a topic, extending a skill, solving a problem and so on. In particular, almost all creative practice involves this general type of research, and often lots of it. In contrast, there is a more limited use of the word research prevalent in academia and about which this article is concerned, where the term refers to uncovering evidence that builds or elaborates upon a theory. Our more limited academic definition also requires that research should be coherent and situated within a broader theoretical framework. In other words, academic research should be situated within a body of extant knowledge, regardless of whether the research supports or challenges existing theory or existing practices.

The distinction we make about general and academic research has parallels to different modes or levels of creativity, what Margaret Boden (1990) refers

to as psychological and historical creativity. In a similar way, general research uncovers knowledge that was previously unknown to the individual but known to the field, while academic research aims at uncovering/creating knowledge that was previously unknown to the field. Given that creative practice is often individualistic, the opportunity for tension between individual and collective understanding through artistic expression and experience is unsurprising. Having outlined what we mean by research for the purposes of this discussion we will proceed to a more detailed discussion about digital media practice.

In our digital media work, knowledge is created and expressed through a conversation between research and practice. The nature of this conversation may vary with different types of practice, but we believe there are consistencies that comprise the character and style of this type of research. The research and practice with which the authors have been most involved is the algorithmic generation of digital content, creatively expressed as audio and visual media art works, and in this chapter we will reflect on our practice of live-coding in particular. But first we will discuss the characteristics of digital media practice more broadly and the opportunities it presents for research.

ĐIGITAL PRACTICE

Digital computing systems have a fluidity and constructability that has made them ubiquitous since arriving on the scene in the middle of the twentieth century. Digital systems are fluid, in that bits can be recycled for use almost indefinitely, and constructible because while their organisation is variable and provisional it is definable by coding in computer programming languages. The fluidity of digital media means that there can be digital representations of various other media including text, image and sound along with processes for the manipulation of them. Like their mathematical cousins, digital systems can represent ideas as formal expressions in code, and this is an important feature for their use in research. The different ways in which media practice exploits digital systems can be simply characterised as *using* or *building* digital systems. By far the greatest use of digital media by creative practitioners is for media simulation where computers are used for drawing, video editing, music production and the like.

Despite media simulation being so popular, we believe that the greatest research potential of digital systems is to combine these with building media by defining processes through the formal expression of ideas in code. The same fluidity that makes digital systems effective for media editing makes them valuable for idea exploration. This is not to say that ideas are not being explored during editing processes, but rather that even greater leverage can be gained by digitising the representation of ideas as code as well as their effect in

media art works. This leverage is present in creative practices that incorporate tool building as meta-creation to exploit the computer as an idea amplifier (Kay and Goldberg 1977), while still making use of its efficient simulation of physical media processes. This combination of tool building and using in practice-led research continues to reflect observations about optimal environments for interactive art by Edmonds (2004: 83):

> Our experience suggests that even today, with all the advances in software, the degree of programming and systems expertise is critical to having more artistic control over the developing process.

The desire for expressive control in artistic work correlates well with the need to be able to express unique and novel ideas in research contexts. The ability for digital systems to enable the articulation of generative processes as a form of meta-creation allows interaction between the expression and exploration of ideas that is fruitful for both creative practice and research endeavours.

APPROACHES TO RESEARCH

There are numerous approaches to research. In particular we see two long-standing traditions that feed into practice-led research: experimental and conceptual research. At the risk of oversimplification, we will use caricatures of different research approaches to highlight contrasts and make our points.

Experimental or ethnographic approaches are based on observation in the world. The sciences have largely conducted research in this way since the Renaissance. There is, of course, variety in this approach, including direct observation often featured in disciplines such as biology and anthropology, through to the measuring of designed interventions in disciplines including engineering, agriculture and social or political activism.

A conceptual or philosophical research approach is based on logic and argument. It relies on measures of internal consistency, resonances with lived experience and, to a lesser extent, popularity for its merit. While this style of research is aligned with the humanities through its use in disciplines such as philosophy, sociology and literature, it also has a strong home in science disciplines including mathematics, cosmology and theoretical physics where empirical measures may be impractical.

Both experimental and conceptual researchers can make significant use of digital systems to aid their thinking and experimenting. Mostly this involves the exploration of hypotheses using computer simulations of their domains. Some obvious examples include aircraft design, weather forecasting, economic modelling and game theory. While this research may use many of the same

tools and skills required by our research in media art, it differs in that, for them, the digital system acts only as a model and the 'hard' evidence is found in behaviours of the real systems they simulate; on the other hand, for us, the computer system is directly in play and its behaviour and outputs are the objects of inquiry. While it can also be argued that for us the 'hard' evidence is also found outside the digital system in the behaviours and opinions of people who experience the music and art produced by our digital systems, it is not our primary concern (but may reasonably be for others) to model the cognitive systems that lead to people's experience of media art.

Our practice-led research draws on elements of both experimental and conceptual traditions. Like the experimental traditions our research creates hypothesis, builds trials and judges their success by evaluating the outcomes 'in the wild' through practice. Like conceptual research our digital systems and aesthetic fitness measures are constructs of the collective imagination, with all the inherent recursiveness and provisionality that characterise dynamic cultural contexts. Not surprisingly, practice-led research approaches like ours seem to best fit the disciplines of creative arts, design and information technology where there is interplay between human culture and physical materiality. The experimental and conceptual dimensions of practice-led research are considered by Richard Vella to be windows onto the creative imagination that produce two layers of metaphorical output, 'the work of art and all its symbolic representations' and 'the theoretical model' (Vella 2003: 4). We are sympathetic to this argument that there are multiple metaphors of understanding, although we differ from Vella's view that the symbolic metaphorical representation precedes the theoretical; rather we believe they are interdependent.

The interdependent nature of experimental and conceptual aspects of research highlights a pronounced difficulty for practice-led research. It requires that the investigator be both a practitioner of some experience and a researcher of some significance. This appears to cause some confusion for arts practitioners who, incorrectly in our opinion, are often of the view that being a practitioner is in some way equivalent to being a researcher. We feel this confusion is rooted in the confusion between general and academic research we outlined above. We are equally suspicious of researchers who believe that they are practitioners. This often leads to unconvincing creative outputs where it is difficult to differentiate between a failure of conception or expression. We see two different tasks. It is possible, and useful, to combine these tasks, but this requires capability in both domains. If the researcher is a poor practitioner then any findings of the outcomes may be of questionable cultural value. If the practitioner is a poor researcher then there is unlikely to be any significant elaboration of existing theory. Research partnerships can often provide complementary skills to bridge this gap. Within aa-cell (see below) we believe we have collectively, and perhaps individually, both researcher and practitioner expertise.

AA-CELL'S LIVE-CODING PRACTICE

As a case study we will discuss our creative practice. We perform music and audio-visual live-coding performances under the name aa-cell, and use the techniques developed through this activity for various media art exhibitions and as input to other research activities using generative media. We have creative backgrounds as instrumental music performers and composers, and have in more recent years established a practice around visual and audio-visual exhibitions. We have experience at creating computer music development platforms and building software tools for making music. Our live-coding performance practice has evolved alongside the development of the Impromptu software which makes this new performance practice possible.

In mid-2005 Andrew Sorensen began developing the Impromptu live-coding environment (Sorensen 2005). At first this work was conceived at a nexus of extant projects authored by Sorensen but soon grew into a self-contained and directed project. The original inspiration for Impromptu was an article authored by Alex McLean entitled 'Hacking Perl in Nightclubs' (McLean 2004). This article outlined a performance practice called live-coding which placed the real-time development of computational algorithms as a central and integral aspect of live computer music production.

Inspired by the notion of real-time music programming, Impromptu was conceived as a tool designed to assist in the construction of musical algorithms in live performance. In the early stages of the development, questions and aesthetic considerations concerning the project could be loosely banded into two separate groups: practical considerations which generally impacted upon engineering-related issues such as scheduling models, signal processing architectures, garbage collection strategies and the like; and more philosophical investigations such as the aesthetic nature of computation, broad notions of time, symmetry and order as well as various other ontological issues. Conspicuously, what was not considered in this early development was any specific musical outcome or stylistic intent. In other words, defined artistic outcomes were not an early focus of the project and tool development started with undefined aesthetic goals. Indeed, the primary motivation of Impromptu's development was a belief that new aesthetic opportunities would arise directly as a result of tool innovation.

This is not to say that there were no creative practice goals established for the project. In fact the opposite was true. Impromptu's early development was marked by rapid progress made necessary by a fixed performance date. In June of 2005, only three months after Impromptu's initial conception, we performed using Impromptu at the Australasian Computer Music Conference in Brisbane, Australia. This hard deadline provided the motivation to realise a significant amount of work in a very short period of time. Another result

of such a short time frame was a clarity and focus for the project, born of necessity.

The importance of such fixed performance dates cannot be overstated. They provide an invaluable force in directing and constraining the project. Further, these performances provide excellent project milestones and are a primary mechanism for measuring the successes and failures of the project at a given point in time. In quite a direct manner it is the artistic practice that frames the successes and failures of the various approaches being followed by the project. These successes and failures then feed back into the iterative project cycle, informing new research directions and opportunities for public dissemination.

As the tool development and usage patterns matured, and in light of the results of early performances, it became clear that our research would encompass issues around both effective tool construction and new ways of representing generative media processes suitable for live-coding. This investigative path involved explorations of effective data and coding structures and theoretical investigations into the computational notation of artistic methods and structures. Outcomes of our explorations are captured as code libraries and performance files, recorded performances and academic publications.

The availability of outputs in multiple forms is a valuable feature of practice-led research. It allows for a diverse approach to the transmission of the ideas developed during the research without having to rely overtly on the preparation of presentational media, such as video documentaries, to reach audiences beyond academia.

REFLECTIONS ON LIVE-CODING RESEARCH

While, as we have discussed, research approaches can be differentiated by their emphasis on the concrete or the abstract, they also vary according to how open-ended or tightly constrained their investigations are. Some research has clearly articulated goals, procedures and measures for success, but our creative practice and research rarely does. Rather the value of our approach is in its agility, enabling us to respond quickly to new insights or changes in context, and in its robust findings that result from having worked through issues of implementation and application as part of the process of discovery.

Research projects typically have a number of stages with, potentially, different degrees of specificity at each. A prototypical experimental research project might devise a hypothesis for testing, set up experiments that control for all variables and measure results statistically. By contrast an ethnographic study may begin by seeking to understand the reasons for a social situation then, after starting, select subjects or a site, record all activities in case they might be significant and analyse data by comparing a series of manual summaries. Our

practice-led research is often closer to the depicted ethnographic approach in that investigations are often loosely formed at the outset, although the context of the study – our creative practice – is usually well defined.

In our digital media investigations the aesthetic criteria for judging success are, like all aesthetic criteria, negotiable within the bounds of established cultural conventions. Projects involve a series of iterations of small-scale tests until a likely candidate for more extensive exploration is arrived at. Often these early iterations result in the development of small software libraries which are leveraged when working on a larger-scale work. The number of such iterations is quite variable and a skill for the practice-led researcher is learning to judge whether an investigative path shows promise or not. A single project often involves several extensive explorations. This iterative hierarchy proceeds until success is clear, failure seems inevitable or time runs out. At the end of this process there are numerous materials for discussion and dissemination including code libraries that can be used for future projects, outputs from small- and larger-scale tests and completed creative works. These data provide a rich resource for discussion, further work, or verification and validation by peers. How general findings can be derived from such data is dependent on a number of factors. In most cases the multiple tests and small-scale works provide sufficient evidence that the processes or ideas developed can have a life beyond one work or context. But it is likely that more work is required to extract from the project those learnings which are specific and those which are more generally applicable. The issue of generalisation, and thus reuse, is important not only for making contributions to society at large through effective knowledge transfer but also to empower the researcher/practitioner in their future work.

In this way our research is highly iterative, not unlike current trends in software design where the exalted status of 'specification' has been somewhat eroded by a realisation that specification is an inherently flawed activity and that development agility with regular reference to outcome requirements is more efficient. Some research design strategies that require upfront specification have similarly been accused of being potentially restricting. A traditional view of scientific research envisions a clearly defined research goal with an orderly implementation plan that results in an outcome clearly demonstrating the success or failure of an initial hypothesis. The problem with this view is its risk adversity and tendency to drift to the centre. As Peter Downton states: 'An often-made criticism of this expectation is that it is a convergent view of research whereas the truly inventive demands a divergent view – a seeking of the unknown and unexpected' (Downton 2003).

In our practice we seek to balance the competing interests of specifiable targets and playful exploration by attempting to rapidly develop, deploy and reflect. By iterating over shorter periods and forcing critique and reflection through regular exposition of our research to both public and academic debate, we feel better able

to explore more novel approaches while still maintaining the healthy pragmatism that performance practice dictates. To quote Steve Jobs, 'real artists ship.'

For us practice-led research is a journey, with an emergent set of stops along the way at points of interest. The journey may take a lifetime, while the individual 'projects' are the paths between points of interest. Snapshots from these points of interest manifest themselves as performances, exhibitions, recordings, websites, presentations, papers and books.

AESTHETICS AND RESEARCH

One of the key points about our creative practice and our research is that aesthetic criteria, understood as subjective human preference based on direct experience (Dewey 1934), are central to the undertaking. The role of aesthetics in creative practice is well established, but not so well established is the role of aesthetics in research. Aesthetics does play a role in many research fields where elegance, simplicity and the like are valued. However, in media art research it generally has a more critical role. In our research the effectiveness of various computational media processes in improving creative output is the most substantial measure of their value. Other criteria for us include the generalisability of a process across many situations, novelty or innovation in the process and the simplicity or parsimonious representation of a process. While it is possible for practice-led researchers to consider their own aesthetic judgement sufficient validation of success or failure, we prefer to use our own judgement for incremental steps but to subject larger-scale works and theoretical advances to peer and public review. Employing collective wisdom as a measure of quality is deeply rooted in both research and arts cultures, particularly in the form of peer review of academic papers or curatorial judgements around art and design. Collective wisdom is also a significant measure in other domains that resist quantitative testing, such as theories about the origins of the universe which are also subject to aesthetic criteria.

Aesthetic judgement is an imprecise measure, it has tendencies toward normative outcomes and expert opinions can be quite divergent. To account for this in our practice-led research we seek peer review regularly and widely, especially when we are unsure about direction, but we also hold fast to a vision for innovation when we are confident about our direction. In the end the results of such practice-led research, like all other research, will stand or fall in the long term by the respect the work commands from others in the field and its impact in the world.

Aesthetic judgement also makes an important contribution to the pragmatism of our research. By focusing on the media outcomes of the research we keep our eye on improving our practice and activity in the world, which keeps

in check the potential for us to obsess overly about interesting technical, theoretical, political or philosophical threads. As well, this perspective leads us to make public a large amount of the practical work resulting from our research. Feedback from these disseminations varies significantly. Performances provide immediate feedback, then a trickle of more considered comment over time and occasionally a formal review in the press. Web-based information and distribution has a qualitative aspect with regard to the frequency and number of visitors and where they are from. We have also found that when work is released in this way we can scan the web for blog posts and other commentary not directed to us but that we can access and accumulate to paint a picture of how the work is received. We welcome controlled testing of our works, which would typically be through statistical tests of algorithms or as reception studies of people engaging with our work, but have so far made limited use of these approaches.

We also regularly engage in the formal academic dissemination processes which are largely text based and see that they have a place in articulating our ideas and representing our work in established academic discourse. We feel that the exposure of our media outcomes offsets the limitation of textual descriptions to some extent and communicates our research findings more clearly than in text alone. As a corollary of this we often present code as part of performances and exhibitions and as libraries that provide another perspective, insight and description of our work.

CONNECTING PERSONAL AND COLLECTIVE UNDERSTANDING

One of the great affordances of creative practice as a research method is the rich opportunity for public dissemination of information. As discussed briefly above in relation to the role of aesthetics, our performance practice offers us the ability to disseminate information as recorded audio/visual media, as software and code, as printed musical score, in written research papers, as presentations to academic and trade conferences and, most importantly, in performance. Performance has proven to be particularly valuable as this is for many people the initial point of contact with our research. We feel that there really is little better way to prove the value of a new musical algorithm than to have someone appreciating it, for example by dancing to it. We believe that the impact of this rich diversity of output is significant as it allows us to reach audiences outside traditional academic forums, to engage with a broader range of disciplines and to evoke greater public scrutiny and comment.

aa-cell have been performing regularly over the past three years throughout Asia and Europe. During this time we have published regularly on a range of topics related to our practice and reciprocally our research has resulted in

new tools for use in our live performances (Brown 2006; Brown and Sorensen 2007; Sorensen and Brown 2008). These performances continue to provide opportunities for reflection and critical audience feedback. Performances also provide the motivation for exploration and discovery as we strive to innovate and provide exciting outcomes for our audiences.

However, it is not for audiences alone that we search for novel approaches, nor is our research based on aesthetic considerations alone. Indeed, while we value highly the role of aesthetic judgement in practice-led research we question the appropriateness of assigning research outcomes only to results based on aesthetics. Rather, the value of our research is in the knowledge embedded in the practice and, by extension, in the computational processes and techniques we use to make it. This is not to say that the quality of the music and visuals is immaterial – indeed we believe it is integral; however, we are interested in the understanding and insights that can arise through the development of new methods for creative expression. We constantly strive to discover new artistic knowledge – be that compositional, cultural, creative or computational – and are interested in how what we learn here might be useful for other artists and applied more widely, especially to other applications of computational systems. We also feel that it is our responsibility to report on that knowledge and to transfer our findings to the broader community, which we accomplish using the full range of media at our disposal.

While it is certainly true that research needs to extend and challenge social norms and cultural practice through innovation, we find that the reality check of actually taking our research into the world is revealing and challenging with regard to the relevance of any innovation we may pursue.

FROM REFLECTION TO THEORY

A critical element of the iterative nature of our creative practice and research is reflection on results. Our experience confirms the findings of Donald Schön that reflection in action is a critical element in developing understanding (Schön 1987). Interestingly Schön's work also grew out of exploring how technologies precipitate innovations and in trying to understand how people accommodate these (Schön 1967).

In general, artistic knowledge is often intuitive and reflection may not occur naturally. Or, perhaps it would be more accurate to say, practical knowledge is inherent in doing and is often considered implicit and as such may not be identified or valued without explicit attention paid to it. It is common for arts practitioners to have significant knowledge without necessarily being able to adequately describe that knowledge. In other words, knowledge embedded in practice is often personal and ineffable. In order to make this personal

knowledge more generally useful a process of reflection and contextualisation is often required. Reflection can help to find patterns that make this personal knowledge more generally applicable and contextualisation helps to place those findings within a broader history of accumulated knowledge. These processes are important because they are essential to transforming personal knowledge into communal knowledge. This knowledge can be accessed through the various presentations of the work – as art works, code libraries, algorithms, written descriptions, critical analysis and commentaries and so on. An integral part of research is this transmission of personal knowledge and understanding that has some novel and general application into communal knowledge.

Shareable knowledge is often expressed as a method, process or theory. The production and dissemination of theory is a distinguishing differentiation between our practice-led research and conventional artistic practice. In our research, theories are frequently associated with patterns of usage, that is with techniques or practices we use regularly. These regular patterns of usage often indicate areas of particular interest in our work and it is through introspection that these patterns may develop into a more general theory or into new techniques and habits. These generalisations, or theories, invariably find their way back into our practice. We feel that this iterative process between expression and reflection is essential to all research and is integral to arts practice.

Experience of the creative output or artefact is also of great importance to understanding the knowledge generated by the research. Firstly, the artefact provides evidence of the knowledge discovered. It stands as a demonstration of the theory and is available as a reference for further investigation and verification. The artefact helps to make the ideas explicit. Secondly, the artefact provides a stimulus for engagement with the knowledge gained. The artefact is integral in communicating the ideas of the research in all its richness and in making the theory available to a wider audience who might otherwise not engage with knowledge in the abstract. In a very real sense practice makes an excellent partner to research, because the benefits of practice-led research flow in both directions.

CONCLUSION

In this chapter we have outlined our approach to research using our live-coding performance practice as a case study. We have argued, based on our experience, that while research and creative practice are not the same activity, there is significant intellectual and cultural benefit to be gained through the integration of research and practice.

Our practice of live-coding has involved both the building and using of digital tools and the development of new representations of musical processes.

We have argued that this provides a way of exploring both the possibilities of established processes and innovation through the construction of new processes. The ease of controlling digital systems through programming software makes this a particularly attractive option for digital media practitioners. The demands of the live-coding performances we undertake provide hard constraints that serve to propel our work forward and add rigour to the results. In addition, the ability to build new software tools enables an agile approach where avenues for investigation can be explored or discarded with minimal effort.

Practice-led research, as we conduct it, is hierarchically iterative with each large step encompassing numerous smaller steps. Progress and direction are guided by aesthetic judgements, enabled by efforts to engage in a healthy dialogue between our own assessments, the opinions of others in our field and those of the broader public. This critical dialogue is facilitated by making our work available in a variety of formats and forums, including recordings of creative work, code examples, academic and informal writing and, especially, live performance. The documentation of our work in these many forms facilitates reflections on the work that lead to the observations of patterns and theories, as well as highlighting opportunities that lead to new work.

So what drives our work? In the end it is our creative desire for artistic expressivity that results in an interplay between actions and ideas. And it is our desire for a productive dialogue with others around this expressivity that leads us to the extensive documentation, reflection and dialogue that positions our practice within a research framework.

The feedback loop between reflection and action, between speculation and experimentation, is fundamental to research in many disciplines and it is an important feature of our work. We suggest that a deliberate and public interplay between imagining and expressing is generally productive as a method for practice and research in the digital media arts.

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