Chapter 1
The Extended Composer
Creative reflection and extension with generative tools

Daniel Jones, Andrew R. Brown and Mark d'Inverno
1.1 Introduction

One of the distinguishing features of human society is our usage of tools to augment our natural capabilities. By incorporating external devices into our activities, we can render ourselves more quick, powerful, and dextrous, both mentally and physically. We are effectively extending ourselves and our practices, temporarily taking on the capabilities of our tools in a transient hybrid form (McLuhan, 1964; Clark and Chalmers, 1998; Latour, 1994).

In this chapter, we look at how the computer can be used as a tool – albeit a tremendously flexible tool – to augment the practice of musical composition. By “composition”, we are talking in the traditional sense: the creation of static, determinate musical works, whose value is in virtue of their content rather than their means of production. Though we will touch on ideas of improvisation, we wish to set aside performance, interactive artworks, and group creativity, and focus on the common situation of an individual artist, developing a body of work through computational means.

By “augment”, we have in mind two different outcomes, both distinct but not mutually exclusive. Firstly, an interaction with a semi-autonomous software instrument can serve to actively extend and reshape our creative behaviours, by responding with its own creative acts, encouraging unusual modes of creation, or enabling those which are normally impossible. Secondly, by mirroring its user’s creative behaviours, such a tool can help us reflect on our own innate stylistic properties, emphasising unseen habits and tropes.

Though both of these sorts of stimulus are possible to some extent via traditional, non-digital means, we argue that computational methods allow us to more comprehensively and precisely support an artist’s behaviour. Generative and adaptive tools can offer new creative routes based on context and past history, harnessing the powerful probabilistic capabilities of the microprocessor, and can selectively target the parts of our creative process that we are particularly interested in.

Going beyond the production of innovative artifacts, we will then take the stronger position that the incorporation of computers can effectively extend us, as composers and musicians. We base this argument on the foundation that creativity is fundamentally a product of an integrated, open system of agencies and influences, exerted not just by our internal drives but by the network of instruments, methods and stimuli that we adopt. Taking the thesis that the means by which we produce an art object impact upon its nature, it follows that amplifying the autonomy of these means serves to broaden the range of objects that we can produce. By observing the successes and failures of this hybrid human-technology system, we can learn new ways of working which may otherwise not have arisen.

In the mainstay of this chapter, Section 1.3, we examine human-computer partnerships from several perspectives, and pull out a number of ways in which they are distinctly different to their predecessors in the non-digital world. In doing so, we formulate a series of taxonomies which can be used to roughly categorise different forms of creative technological partnership.

Before doing so, we will take a step back, and consider the theoretical building blocks from which this field has emerged.

1.1.1 Thinking through tools

“People need new tools to work with rather than tools that ‘work’ for them.” (Illich, 1973, p10)

In daily life, the use of tools is second nature to us. We seamlessly conduct our goal-orientated activities via physical objects without the slightest awareness that we are doing so. So accustomed are
we to the use of knife and fork, computer keyboard, can-opener and door-key, that the only times we become aware of their presence is when they malfunction and interrupt our activity (Heidegger, 1977).

Through the complex mechanical and chemical mediation of biro on paper, we are able to convey structures of thought to unseen recipients. Consider the example of a drawn diagram. Relationships between spatial and temporal elements can be relayed clearly and concisely, with a reasonable expectation that the message will be successfully received. Moreover, by working through the details of the diagram on paper – through sketching, drafting, and observing the formalised realisation of our ideas – we can use the process of diagramming as a means to develop our thought. Yet, the role of the pen is completely invisible throughout. If we were continually distracted by the task of gripping the biro and steadily applying its nib to the paper, the task of relaying our ideas would be insurmountable.

In a well-known encounter, the physicist and Nobel laureate Richard Feynman is discussing the archive of his own pen-and-paper notes and sketches. When asked about these “records”, Feynman retorts:

“...it’s not a record, not really. It’s working. You have to work on paper and this is the paper.” (Clark, 2008, pp. xxv, original emphasis)

The implication here is clear. This physical transduction of ideas – through arm, hand, pen, paper, and back to the mind via our optical apparatus – is not simply a trace of what is going on in our mental hardware, but an integral part of the thinking process. The application of pen on paper cannot be considered a passive artefact but as a fundamental machinery responsible for “the shape of the flow of thoughts and ideas” (Clark, 2008).

The above case is cited as an exemplar of what Andy Clark terms the “extended mind” hypothesis (Clark and Chalmers, 1998). In brief, this argues that the adoption of pen and paper and other such “cognitive scaffolds” serves to shift the actual processes of thought outside of our brains and bodies, and that our sensorimotor interactions with can-openers and door-keys are embodied forms of thinking. We can consider ourselves as “open-ended systems – systems fully capable of including nonbiological props and aids as quite literally parts of [ourselves]” (Clark, 2003). Just as our mental conditioning serves to subtly affect our reactions to tasks, so too do the nuanced differences in the form and function of the physical tools through which we act.

Feynman was in good company in his observation. A century earlier, Nietzsche’s adoption of the typewriter had impelled him to observe that “[o]ur writing tools are also working on our thoughts” (Kittler, 1999). Something new emerges from this formulation that we will return to shortly: that the causal relationship between tool and user is fundamentally reciprocal. We live through our tools, and our tools shape our experiences. This is a feedback loop. It is our belief that the feedback loop is key to the creative process (McGraw and Hofstadter, 1993); the reader will observe them cropping up repeatedly throughout this chapter.

Needless to say, many eras of industrial development have provided us with a menagerie of tools far more exotic than the typewriter, biro, paintbrush or can-opener. In the context of the present chapter, we will focus on one specific example, albeit the most general-purpose example that we can currently imagine: the digital computer.

1.1.2 The computer as meta-tool

The traditional conception of a tool is an implement which provides us with mechanical means to carry out some task that exceeds our natural capabilities; consider unscrewing a nut, or levering open a crate. Epistemic tools, such as the abacus, can perform the same role in the domain of
cognition (Norman, 1991; Magnusson, 2009). When shifting physical tokens around in space, we are simultaneously translating their state into a symbolic form in order to consider their interactions as constituting a calculation.

The information age has heralded a qualitatively new kind of cognitive extension, in the form of digital computing devices. Equipped with a programmable computer, and given an appropriate physical interface, we can effectively produce any epistemic tool that we can conceive and formalise. The computer, therefore, is a meta-tool, a platform upon which we can build and use new forms of cognitive scaffolding.

The tools that we construct upon this platform do not themselves have to be static and single-purpose. Their functionality can adapt to new contexts – even those which have not been anticipated ahead of time. Software components can be modularised and aggregated, resulting in complex assemblages which incorporate the features of multiple sub-tools.

Moreover, we can confer upon our computational tools a degree of unpredictability – a most useful property when seeking to catalyse innovation. In the non-computational world, it is difficult to engineer technology that behaves unpredictably in a useful or interesting way; the most obvious examples remain in the realms of gaming and gambling. With digital pseudo-random number generators, however, we can harness the power of chance processes and deploy them in targeted contexts. Smart applications can respond with extended, nonlinear outputs, opening up vistas of possibility in comparison to the predictable one-to-one response of a traditional tool. Sufficiently complex devices can effectively become autonomous: able to carry out tasks and pursue goals without our supervision.

Here, a distinction should be made which will be set aside for much of our subsequent discussion. We will tacitly be discussing two kinds of tool, distinguished by their motivation and methods of production: those which are designed for use by a general public, and those which are built for a bespoke purpose or practice. Most of this treatment will assume that our tools are “black boxes” (Latour, 1994), closed to functional modification and analysis; for all intents and purposes, these hard-wired devices can be considered more akin to the traditional concept of a tool.

1.1.3 Digital partners in creative practice

Looking towards the sphere of contemporary art practice, we have seen technology emerge at countless new loci, bringing about new functional relationships and modes of engagement (Brown, 2000). As a case in point, musical recording and production is now dominated by digital processes. An artist can produce professional-quality albums using domestic computers, collaborating and distributing their work via the medium of the internet. Interfaces such as The Freesound Project\footnote{http://www.freesound.org/} enable copyright-free sound samples to be shared globally, with tagging and “folksonomy” classification to track relationships between sounds and locate similar material.

Lubart (2005) proposes a loose taxonomy of the roles that we can metaphorically consider a computer as playing within a creative context: as a nanny, taking care of routine tasks and freeing up our cognitive faculties for the real creative grist; as a penpal, aiding the process of communication and collaboration; as a coach, providing exercises and collections of related knowledge through a targeted database system; and as a colleague, working as a “synergistic hybrid human-computer system” to explore a conceptual space in tandem. Though some of the associative elements of the ‘coach’ role are relevant to this discussion, we are here mostly concerned with the latter case, in which the computer
is embedded within the same creative framework, co-operating to create a work through a succession of interactions, that form a partnership between creator and computational system (Brown, 2001).

The capacity for autonomy in computational systems can allow them to operate with distinct agency in the creative process, a property which we will henceforth describe as generativity (Galanter, 2003). When using generative processes, the artist sets up a system with a given set of rules for its ongoing autopoiesis. These rules are then carried out by computer, human, or some other enacting process. A purely generative work involves no subsequent intervention after it has been set in motion; a work with no generative elements has no capacity for autonomous action, and so requires continual intervention to operate.

The class of systems that we are interested in lies somewhere between the two. A system in this class is interactive, but does not produce an output which is completely predictable from an artist’s input; nor does it disregard this input and follow only its internal logic. Its output is mediated through some predetermined structure or ruleset – such as the statistical mechanisms of François Pachet’s Continuator (Pachet, 2003) – but should always follow somehow from the previous marks of the artist (and, in some cases, the computational system itself).

The broader implication of the discussion in this chapter is about creative interactions with objects that have agency. Philosophically, “agency” is typically aligned with intent, goal-based planning, and even consciousness. It is not this strong type of agency that we are attributing to generative art systems. We have in mind a broader, anthropological description of agency, such as that provided by Gell (1998) in relation to art objects. Here, agency is attributed to anything seen to have distinct causal powers:

> “Whenever an event is believed to happen because of an ‘intention’ lodged in the person or thing which initiates the causal sequence, that is an instance of ‘agency’.” (Gell, 1998, p17)

Such a liberal definition allows agency to be attributed even to fixed, inert objects such as coins, cups (d’Inverno and Luck, 2004), Rubik’s Cubes and doilies – in fact, many objects which are more inert than the class that we are interested in.

The particular agency that we will focus on is the ability of generative systems to demonstrate behaviour that can be classified as productive. By partnering with an interactive, generative system, we enter into a form of distributed agency, incorporating multiple distinct productive drives.

### 1.1.4 Conceptions of creativity

The concept of ‘creativity’ is quintessentially slippery, steeped in vagueness and paradox. Through imaginative faculties, we bring into being an original work or concept which is somehow of value, either aesthetically or pragmatically. Such originality seems to stake a claim for inexplicability: something radically new and unforeseeable has been produced from nothing at all, out of a conceptual ether, with its source and productive process hidden behind a veil.

In a book dedicated to creative practices, we will not dwell too much on the varying conceptions of creativity itself lest we retread familiar ground; see the chapter by ??? for more in-depth coverage. The terms and assumptions with which we are working must be clarified, however, to ensure our argument remains coherent.

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2 For examples, see the crystal growth of Roman Kirschner’s installations, the Condensation Cube of Hans Haacke, or the recent installation by Céleste Boursier-Mougenot’s in which zebra finches were given free reign over a gallery of amped-up electric guitars.
We will be working in the framework laid down by Boden (1990), whose definition of a creative act is one that expresses the dual aspects of *novelty* and *value*. Rather than focus on cases of creativity characterised by the unpredictable spark of the “a-ha!” moment, the body of Boden’s thesis examines the more commonplace process of *exploratory* creativity, in which we progressively work at the limits of a problem, exploring the “conceptual space” (Gardenfors, 2000) in which it is located. Unlike in puzzle-type problems, in which we can clearly formulate the problem, this search need not be in response to a well-defined question. The objectives may be fuzzily-formed, unknown, or even nonexistent.

As our awareness of a given cultural frame is inherently limited, conceptual spaces are themselves relative to the beholder. Following from this, Boden suggests two kinds of creative discovery (Boden, 1990): psychological- or *P-creativity*, in which an act is creative (that is, innovative and valuable) from the perspective of its producer; and historical or *H-creativity*, in which an creative act is novel to the entirety of its historical frame – take Picasso’s first cubist works, or Pythagoras’ formalisation of musical principles.

A corollary of this distinction is that a person can be genuinely P-creative, uncovering part of a conceptual space that is new to them, whilst retreading conceptual ground which is familiar to the wider world. Creativity can only be properly understood relative to a body of knowledge. In general, we will tacitly be discussing P-creative interactions between a person and computer, but – given that a human artist is still making fundamental artistic decisions – there is no reason that these productive relationships couldn’t equally give rise to H-creative acts.
1.2 Historical Context

There is an extensive ancestry around strategies to provoke and direct creative action. A commonplace example is the varied pursuit of inspiration. A dressmaker, bereft of creative direction, might browse the shelves of the haberdashery for ideas in the form of patterns, fabrics and accessories. A web designer may surf through collections of layouts or graphic images; indeed, at the time of writing, popular social bookmarking site Delicious lists over 4,500,000 web pages tagged with the keyword ‘inspiration’. Such creative foraging is so ubiquitous across the creative industries that countless published collections are available – within design, fashion, architecture and advertising – whose raison d’être is the provision of creative nourishment.

In making the switch to outside sources of inspiration, we are effectively abandoning our internal cognitive search and delegating our ideational activity to the external world: another case of the extended mind (Clark and Chalmers, 1998) – or, rather, the extended imagination. We will shortly develop these ideas further.

Many approaches, of course, demonstrate a more explicit intentionality than disengaged browsing. Csikszentmihalyi (1992) recounts an ethnographical report of the Shushwap Native American practice of uprooting and relocating its village every 25-30 years. In doing so, they introduced novel, chaotic challenges to their living practice, ensuring a continual enrichment of cultural cycles.

More recently, the Surrealist writers sought to subvert the conscious mechanisms of decision-making by encouraging ‘automatic’ drawing: the accumulation of pen strokes produced without rational control, whose result was claimed to express the subconscious or paranormal.

The chance operations of the Black Mountain College and the indeterminate works of the Fluxus group formally introduced aleatoric processes as a means of creative inspiration and delegation. The forefather of both schools is composer John Cage (1968), whose comprehensive engagement with chance, randomness and indeterminacy informed the work of countless members of the avant-garde (Pritchett, 1993).

La Monte Young, a student of Cage’s, was a key part of the early Fluxus movement. “An Anthology of Chance Operations” (Young, 1963) is perhaps the paradigmatic text, collecting numerous instructional scores and “open form” pieces: those which leave significant constitutive elements open to choices made by the performer. In doing so, certain formal structures are imposed – some very loose, some very precise – which can act as catalysts or frameworks for artistic innovation.

The improvised painting of the Cobra group drew up a manifesto describing the process of “finding” a painting through its production, seeking an art which is “spontaneously directed by its own intuition” (Smith and Dean, 1997, p108). Later, the American abstract expressionists adopted practices such as action painting, aleatoric and combinatorial techniques, thereby surrendering unmediated authorship of their works (Smith and Dean, 1997, p109).

A broader approach is taken by Eno and Schmidt’s ‘Oblique Strategies’ cards (Eno and Schmidt, 1975), which indirectly suggest escape routes from creative deadlock via koan-like prompts. Similarly, sets of lateral, discipline-agnostic “heuristics” are collected in the works of Pólya (1971) and de Bono (1992). A heuristic can be thought of as a problem-solving rule of thumb; its literal translation, as Pólya notes, means “serving to discover” (Pólya, 1971, p113). Rather than offering a concrete, logically rigorous method, heuristics provide imprecise but plausible ways to tackle a problem. In this case, they suggest formal approaches, in the form of rhetorical questions such as “Have you seen it before?” (p110).

3 http://www.delicious.com/
A markedly different tack was taken by the Oulipo movement, whose exercises in constraint offer new creative routes to writers – paradoxically, through restricting the parameters of their production (Matthews and Brotchie, 2005). Similar constraints were present in the theatre of ancient Japan, whose ritualistic practices subscribed to a well-defined set of norms (Ortolani, 1990). Submitting to external demands can be seen as another form of delegating artistic decisions, trading the openness of a blank slate for a more focused problem domain.

1.2.1 Computational strategies and algorithmic aides

Historically, the potential for deploying computational technology in a creative context did not escape even the earliest computer scientists. Alan Turing’s fascination with such ideas lead to the establishment of the field of artificial intelligence (Hodges, 1985). Partly due to the limited success of artificial intelligence in developing fully autonomous computational systems, and partly because of the increased access to computing tools by artists and designers, experiments with creative partnerships between artists and computing systems began to flourish.

Early experiments in computer-aided composition are successively described by Hiller (1968), Chadabe (1984) and Ames (1987), with early experiments building on statistical methods and generate-and-test techniques using models of musical procedures. Koenig (Laske, 1981) and Xenakis (2001) incorporated more thoroughgoing stochastic constituents in their composition, with scores and synthesis determined by multi-level algorithmic processes. So too did Cage in a handful of later multimedia works, including HPSCHD, a collaboration with Lejaren Hiller (Pritchett, 1993, p159). Cornock and Edmonds (1973) describe the transformations that interactive tools were already effecting on the roles of both artist and audience, written in the terminology of “art systems” and multi-agency processes.

In the last quarter of the 20th century, increased computational power has enabled the wider use of real-time interactive systems (Rowe, 1993; Winkler, 1998) and generative simulation systems based on physical and biological processes (Berry, 1997; Brown et al, 2010). Other major touchstones of algorithmic composition include Karlheinz Essl’s Lexikon Sonate (1992), David Cope’s Experiments in Musical Intelligence (1996), and George Lewis’s Voyager (2007). For a fuller history of algorithmic composition, we refer the reader to Collins (2009). For a reference text covering many specific methodologies used within the field – generative grammars, genetic algorithms, cellular automata, and so forth – see Nierhaus (2009).

Interactive tools for musical creativity have begun to make their way into popular culture in a number of forms. Brian Eno (1996) has historically championed the cause of generative music through his significant media profile, recently creating algorithmic soundtracks for games such as Electronic Arts’ Spore. The translations of his ideas to the popular iPhone and iPad formats, in interactive ambient sound apps such as Bloom, have attracted high audience figures. At the time of writing, numerous novice-friendly audio apps are proliferating for mobile platforms, no doubt driven by the widespread access to such devices and their compelling touchscreen interfaces.

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4 http://www.spore.com/ftl
5 http://www.generativemusic.com/
1.3 The Human-Computer Partnership: Characteristics and Categories

Interaction with a generative system inhabits an unfamiliar midpoint on the spectrum of creative relationships. It resides somewhere between tool usage and human collaboration, inheriting some characteristics of each and generating some of its own.

In this section, we will explore the partnership with generative computational systems from a number of distinct but related perspectives, with a view to a fuller appreciation of the potential opportunities and hazards that such partnerships can yield. These perspectives do not follow a strict progression, but are ordered based on an attempt to guide the reader intuitively, beginning with abstract principles and ending with issues of assessment and evaluation.

- **Feedback** (1.3.1)
  *In which* we examine the abstract process at the heart of creativity: the feedback loop. Multi-level feedback cycles constitute the essence of individual creative practice and the dynamic cultural backdrop within which it resides. We break this feedback cycle down into processes of *generation* and *evaluation*, and discuss some ways in which artificial augmentation is used to distort these processes.

- **Exploration** (1.3.2)
  *In which* we fill in the concrete details of how a feedback loop may be expanded by algorithmic means, by adding autonomous computational agency, capable of introducing novelty and encouraging serendipity.

- **Intimacy** (1.3.3)
  *In which* we provide counterbalance to this blooming diversity-generation by arguing that we do not wish our partners to be completely unpredictable; we need to develop trust in a creative relationship. This section concerns our ability to learn and understand an autonomous instrument, touching on embodiment, tacit learning, and flow. We provide a taxonomy of the predictability of instruments: that is, the degree to which an output can differ from our expectations for any given input.

- **Interactivity** (1.3.4)
  *In which* we introduce five classes of productive dialogue that can be entered into with a computational tool or instrument: *directed, reactive, procedural, interactive* and *adaptive*.

- **Introspection** (1.3.5)
  *In which* we consider a secondary operational role of interactive tools. Aside from enabling us to do qualitatively new things, an active instrument can act as a conduit for introspection, allowing us to reflect on our existing creative habits by seeing them from a new perspective.

- **Time** (1.3.6)
  *In which* we review different timescales of creative feedback loop: seconds, minutes, months and decades.

- **Authorship** (1.3.7)
  *In which* we reflect upon issues of authorship and non-human agency, and the surrounding controversies. Creativity is often seen as sacred ground; some moral objections are therefore discussed.

- **Value** (1.3.8)
  *In which* we discuss the differences and difficulties, if any, in assessing the aesthetic value of an art object which has been produced with computer-aided techniques. On the flipside to this, we argue that it is equally important to properly design and evaluate the tools which are used to these ends.
Throughout this coverage, we will continue to draw on key examples from the field of algorithmic composition and interactivity.

1.3.1 Feedback

“Already at the very beginning of the productive act, shortly after the initial motion to create, occurs the first counter motion, the initial movement of receptivity. This means: the creator controls whether what he has produced so far is good.”

– Paul Klee, *Pedagogical Sketchbook* (Klee, 1972, p33)

Feedback is at the very heart of creativity, from Klee’s “initial motion” to the point at which we stand back and decide that a work has reached its finished state. We oscillate back and forth between creative acts and the reflection upon those acts, with each new mark, note, or theorem offering subtle potential to alter the direction of a work. This is a feedback loop, in which data about the past informs the events of the future. After each new brushstroke, what was just about to happen is now in the past, and will affect whatever we do next. It is this short cycle of repetition, in which the output of one act become the input for the next, that constitutes feedback.

McGraw and Hofstadter (1993) describe this very cycle as the “central feedback loop of the creative process”:

Guesses must be made and their results are evaluated, then refined and evaluated again, and so on, until something satisfactory emerges in the end. (McGraw and Hofstadter, 1993, p16)

If we reduce this to its most abstract form, we are left with two elements, which run until we are satisfied with the outcome:

- **generation** (of the guesses that are made), and
- **evaluation** (of their results)

We switch from one to the other, alternating between the generation of new elements and the evaluation of the piece in its entirety.

\[ g \rightarrow e \rightarrow g \rightarrow e \rightarrow g \rightarrow e \rightarrow \ldots \]

The underlying goal of many of the strategies described in Section 1.2 is to tinker with the makeup of these generate/evaluate activities, artificially expanding or warping our typical creative trajectory. Amplify the pool of material available for generation, and we increase the creative scope (Figure 1.2); constrain the pool, and we free up our decision-making faculties in favour of a deeper exploration of some particular conceptual subspace. Likewise, imposing a particular creative event enforces a radically new situation which demands an appropriate response, potentially introducing unanticipated new possibilities.

Much of this “generation” is internalised, a product of the free play of our imaginative faculties. By considering a collection of stimuli in the context of a given project, we can assess their potential
to be incorporated. Disengaged browsing and creative foraging, thus, throw new [material] elements into our perception, enriching the pool of generative source material.

The likes of Oblique Strategies (Eno and Schmidt, 1975) and Polya’s heuristics perform a similar operation, but in terms of more broad, lateral cognitive structures. Taking a sample of the Strategies:

- Change ambiguities to specifics
- Don’t avoid what is easy
- Go to an extreme, come partway back
- What would your closest friend do?
- Magnify the most difficult details
- Remove a restriction
- Is it finished?

These directives advocate a change to the parameters that we have tacitly adopted for our generation/evaluation routines. Some serve to highlight hidden, potentially artificial constraints; others suggest explicitly imposing such constraints, to see what pops out.

In contrast with the dressmaker’s browsing, which expand the pool of creative content, these strategies amplify the diversity of formal ideas to utilise in a project. They feature analogy-based approaches, which can suggest metaphorical linkages with other domains, working on the presupposition that certain systemic structures can bear fruit when applied in a new field.

Fig. 1.2 Transforming the feedback loop using artificial methods. With generative (and even traditional) tools, we can amplify or restrict the pool of potential creative material, or impose a radically new direction.

1.3.2 Exploration

“Your mistake was a hidden intention”


Let us return to the analogy of creativity as a search within a conceptual space, probing the dimly-lit peripheries of a problem for undiscovered terrain.

To take a purely logical stance, we can imagine such a search as the sequential application of deductive rules: if I have just played the dominant seventh, then I should next play the major tonic,
except in the case that I wish to avoid immediate resolution, in which case I will play the major fourth.

Many theoretical models of cognitive processes, prominently Markov chains (Wiggins et al, 2009), follow such a rule-based approach, albeit often with some non-deterministic elements to introduce statistical uncertainty and variance.

If we possessed such a cognitively-encoded ruleset for a given domain, and imaginative acts were simply the derivation of new consequences of these rules, it seems at first glance that the creative field would remain static and invariant. On a small scale, a fundamental source of diversity lies in relaxing or bluntly flouting these rules. Citing Thelonius Monk and his endeavours for his music “to find other places”, Prévost (2004) suggests that the aspects of chance in an improvised musical performances are opportunities to make unforeseen errors which can subsequently be followed and investigated. He recounts a tale in which Monk, frustrated with an improvised performance, complained that he had “made all the wrong mistakes” (Prévost, 2004) – indicating the existence and appeal of correct mistakes, which may aid us in this creative search.

To follow this path intentionally, then, we are effectively designing for serendipity (André et al, 2009; van Andel, 1994): tacitly encouraging or inducing “correct mistakes” as a route to unforeseen discoveries and new creative terrain; introducing “disorder”, as John Cage ordained (Cage, 1968). One piece of generative music software that exploits these characteristics is Intermorphic’s Noatikl6. This system relies heavily on constrained stochastic choice in selecting musical values and is advertised as a tool to “generate new ideas” and “break composer’s block” (Cole and Cole, 2008), providing an explicit use of generative processes as a way of developing unexpected alternatives and jolting composers out of familiar habits and patterns.

A given creative act can generate a class of output. We may have complete, trained control over our actions, or we may surrender some control to chance. This surrender may be accidental (we slip and stumble) or intentional (automatic writing, heavy air notes, chance processes: anything with

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6 http://intermorphic.com/tools/noatikl/
unpredictable or uncontrollable execution). Both these kinds of accident – intentional accidents and accidental accidents – can be retrospectively incorporated into the work.

Let’s clarify what we mean by looking at a couple of examples. Native Instruments’ Absynth\(^7\) is a virtual synthesiser, with scores of user-adjustable parameters to control a range of synthesis techniques. Alongside these determinate controls, Absynth has a feature called ‘mutate’. When triggered, this nudges its parameters in random directions. Given the complex web of relationships between parameters, the output can thus be wildly unpredictable, whilst retaining a link to the previous settings. This may prompt the user to make further adjustments or suggest new sonic directions, purely through chance discoveries.

The tabletop reacTable (Jordà et al, 2007) device likewise has a ‘reacTogon’ instrument which uses chance processes in hands-on interaction. Sequences of events are generated by nodes on a hexagonal grid, which collide and intersect to create unpredictable chain reactions, generating note sequences which could not be anticipated ahead of time. Effectively, we are exploring the space of interactions with a partner system, making use of its inherent scope for serendipity.

The fundamental benefit of all of these systems is that they can push us into new forms of creative adventure, by augmenting both the generative and evaluative aspects of the central creative loop. By introducing processes from outside the canon of traditional musical practice, we are injecting innovation which would not simply have occurred through incremental, exploratory development. Such processes can generate new fragments of material that can be assimilated and modified by the artist.

Björk recounts an anecdote regarding composer Karlheinz Stockhausen and his everyday pursuit of the unfamiliar.

Stockhausen told me about the house he built himself in the forest and lived in for ten years. It’s made from hexagonal pieces of glass and no two rooms are the same, so they are all irregular. It’s built out of angles that are reflective and it’s full of spotlights. The forest becomes mirrored inside the house. He was explaining to me how, even after ten years, there would still be moments when he didn’t know where he was, and he said it with wonder in his eyes. And I said, “That’s brilliant: you can be innocent even in your own home”, and he replied, “Not only innocent, but curious.”

We experience a similar effect when we switch to an non-standard interface to composition. From experience, the first experiences with a system such as the reacTogon or McCormack’s Nodal (McCormack et al, 2008) give rise to a creative play which pushes the user towards unfamiliar terrain. By overcoming the habits formed when repeatedly using a given interface or mode of creative operation, our curiosity and openness are restored.

Alongside enhancing the creative scope of skilled artists, computational artistic systems have a second affordance: they can support or enhance creative activities for inexperienced artists (including children, the disabled, or those unconfident with or untrained in artistic practices). There is enormous potential for this latter advantage with the explosion of user-generated content for internet-based media services, such as YouTube and Flickr, and for creating digital artefacts to share on social networks, such as Facebook. Despite the fact that some content on these sites is created with significant effort and skill, mostly users prefer quick and easy processes. As a result, the point-and-shoot-and-upload features of digital cameras and video recorders are increasingly popular. Some generative systems are beginning to add value for these users: for example, Animoto.com, which automatically generates video based on still images and music uploaded by a user. The impact of generative systems is likely to be both subtle and profound in these systems, and as information can increasingly be ‘mashed-up’ from various sources, systems for assisting with these processes are likely to be important. However, it is not yet clear what the impact is or best practices might be around these innovations to our creative culture.

In all of these cases, the “central loop of the creative process” McGraw and Hofstadter (1993) is being widened to incorporate agencies which are not present in what may be considered “normative” creativity. The Romantic conception of an isolated painter, toiling for weeks over a canvas in visual engagement with his subject, makes way for a hybrid, collective art intelligence, whose output is the result of an internal tussle between heterogeneous and nonaligned forces.

1.3.3 Intimacy

To enter into a meaningful and enduring relationship with a tool or creative partner, we must secure a degree of trust in it: trust that its responses will have some relevant correlation with our own, rather than it disregarding our inputs and behaving completely autonomously; trust that we can gain an increasing understanding of its behaviour over time, in order to learn and improve our interaction with it, either through embodied (tacit, physical) or hermeneutic (explicit, neural) knowledge; and, in the case of active instruments or human partners, trust that its activity will continue to generate interest through autonomous creative exploration.

Essentially, what we are seeking is for our partner to behave in ways which are novel but not too novel. This response pattern is described by the Wundt curve (Figure 1.4).

Interaction with generative systems for creative tasks such as music, art or design are often premised on the duality where the computational system generates material and the human acts as a fitness function selecting or rejecting materials and arranging them into a final product. This would be a tiresome process if the generated material varied widely from what was required. Consistency of operation also improves the confidence of an artist in the output of a generative system. Confidence and predictability in the generative system contribute to the development of a partnership and, ultimately, to the productivity and quality of the work.

As well as paying attention to the predictability of results it is also clear that all designed artifacts, including generative systems, are biased by decisions made by their developers and by the materials and processes they use. We must align our thinking with the patterns and prescribed methods that underlie the design thinking of the system Brown (2001). Understanding these patterns is necessary to get the best out of the system.

For an effective partnership with a computational system, we suggest that it is necessary to accept such biases as characteristics, rather than errors to be fighting against. Again, taking a musical instrument analogy, good musicians learn to work within the range of pitch, dynamic and polyphony of their instruments as they develop an expressive capability with these tools.

A quite different difficulty lies in the material status of our tools. Magnusson (Magnusson, 2009) argues that acoustic and digital instruments should be treated with categorical difference, with implications for our ontological view of their interfaces. The core of an acoustic instrument, he argues, lies in our embodied interaction with it, realised through tacit non-conceptual knowledge built up through
physical experience. A digital instrument, conversely, should be understood hermeneutically, with its core lying in its inner symbolic architecture. Tangible user interfaces are “but arbitrary peripherals of the instruments’ core” (Magnusson, 2009, p1).

The implication of this is that our interactive habits are developed quite differently with a digital tool. When playing an acoustic instrument, we can typically offload a large amount of cognitive work into muscle memory, which – with practice – can handle common tasks such as locating consonant notes and moving between timbres. An alternative to this development of embodied habituation for computational systems is the use of automation and macros that can capture repeated processes and actions.

This type of process encapsulation is inherent to many generative computer composition systems including Max/MSP\(^8\), Supercollider\(^9\), Impromptu\(^10\) and so on. The hierarchical arrangement of ‘motifs’ or ‘sections’ that this type of encapsulation allows is well suited to music compositional practices. These come together in an interesting way in the Nodal\(^11\) software by McCormack et al, in which generative note sequences and cycles can be depicted as graphs of music events (nodes). Nodal allows for the creation of any number of musical graphs and for the user to interact with them dynamically. The behaviour of individual nodes can be highly specified, providing confidence in the detailed music playback, while musical fragments and riffs can be set up as independent graphs that ‘capture’ a musical idea. However, despite this level of control and encapsulation the interactions between nodes and graphs can give rise to surprisingly complex and interesting outcomes.

1.3.4 Interactivity

One of the affordances of computational technology is the shift from single-note instruments, in which one action results in one musical response, to “hyperinstruments”, which can respond to actions with multiple, structured events. This can be seen as high-level composition, working on the level of whole phrases or pieces rather than individual sound events.

McCullough (1996) advises that dynamic control over high level operations rather than low level details yields a sense of control over a complete process in tool usage generally. This kind of meta-control is typical of manipulating generative processes. Beilhartz and Ferguson argue that the experience of connection and control for generative music systems is critical; “The significance of generative processes in an interactive music system are their capability for producing both a responsive, strict relationship between gesture and its auditory mapping while developing an evolving artefact that is neither repetitive nor predictable, harnessing the creative potential of emergent structures” (Beilhartz and Ferguson, 2007, p214).

As a consequence of the more structured possibilities for tool-use relationships, many different kinds of control flow exist within computational creative tools (Figure 1.6). Awareness of these and how they might be combined within or across a generative system is an important step toward a better understanding of the range of creative relationships that are possible.

A directed tool is the classical form of computational application: controlled through a typical HCI device (mouse, keyboard, touchscreen), these are used to mediate creative acts onto a screen or printing device. The user exercises control over the outcome of their actions, which is produced

\(^{8}\) http://cycling74.com/products/maxmspjit\(^{9}\)ter/

\(^{9}\) http://supercollider.sourceforge.net/

\(^{10}\) http://impromptu.moso.com.au/

\(^{11}\) http://www.csse.monash.edu.au/ cema/nodal/
(effectively) immediately. Typical examples are desktop applications for graphics, musical composition or word processing, such as Adobe Photoshop and Sibelius. Such a tool should operate predictably and learnably.

A **reactive** tool senses a user’s creative acts, through a microphone, camera or other sensor, and responds proportionately – often in another sensory domain. A commonplace example is the real-time visualisation of music, as exemplified by the likes of Apple’s iTunes\(^{12}\) media player. No expectation is produced for further development within the aesthetic narrative, though the user may be able to learn and master the mode of interaction.

Other examples of reactive tools include Ze Frank’s v\(_{draw}\)^{13} web application, which maps sound volume levels into drawn lines (see Figure 1.5). Amit Pitaru’s *Sonic Wire Sculptor*\(^{14}\) performs the same operation in the other direction, transforming drawn 3-D structures into looping sound.

A **procedural** system involves a fixed process, typically designed by the user, which unfolds gradually when triggered. Examples include the phasing techniques used by Steve Reich, Iannis Xenakis’ physical simulations of particle clouds, and the plant growth models of Lindenmayer systems (L-systems) (McCormack, 1996). Though some indeterminate elements may be present, and a seed configuration may be input by the user (as in the case of L-systems), no subsequent intervention is required or expected.

An **interactive** tool, conversely, tracks its users actions and responds to them within the same ‘canvas,’ creating the potential for further development upon the system’s actions. This ‘canvas’ may be an acoustic space, the virtual page of word processor’s virtual page, a physical , or . It then becomes possible that we can respond to its output, potentially reshaping its direction as well as our own. The outcome is a symbiotic partnership between system and user, in which the attribution to each becomes blurred. An example is the MetaScore system (Hedemann et al, 2008) for semi-automatic generation of film music via control of a generative music systems parametric envelopes.

An **adaptive** tool extends beyond the interactive by developing over a time period, changing the dynamics of the system’s responses according to the history of its behaviours (and those of its user). This introduces a behavioural plasticity which allows its activity to remain relevant and novel to its user. Tools falling into this class are those which make use of dynamical systems such as neural

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\(^{12}\) http://www.zefrank.com/v\(_{draw}\)\_beta/

\(^{13}\) http://www.zefrank.com/v\(_{draw}\)\_beta/

\(^{14}\) http://pitaru.com/sws/
nets Miranda and Matthias; Bown and Lexer; Jones et al, evolutionary algorithms (Brown, 2002) and stateful ecosystems (McCormack, 2003; Jones, 2008; see also the chapter by McCormack, this volume).

\[ \text{Directed} \quad \text{Reactive} \quad \text{Procedural} \quad \text{Interactive} \quad \text{Adaptive} \]

\[ u \quad c \quad s \quad u \quad c_1 \quad c_2 \quad s \quad u \quad c \quad s \quad u \quad c \quad s \quad u \quad c \quad s \]

**Fig. 1.6** Types of interactive dialogue. \( u \) is the user or artist; \( c \) is the “canvas” or creative space; \( s \) is the computational system.

In this chapter we are especially concerned with the *interactive* relationship between creator and generative system, perhaps with elements of other kinds of relationships. Interactivity with a generative system provides a level of partnership that goes beyond what is typically labeled as Human Computer Interaction (HCI) in virtue of the agency inherent in the generative system.

### 1.3.5 Introspection

Early theorists of computer music – partly, no doubt, as a consequence of the technological limitations of the era – placed emphasis on the purification of the compositional process, as a way of better understanding our own behaviours, either personal or cultural (Supper, 2001; Hiller, 1968; Ames, 1987). To model the processes tacitly underlying a existing musical system, we must formalise them in an effectively computable form; that is, transform them into a set of algorithms, with which we can generate new pieces which fall into the same class. By creating a computer simulation which executes these algorithms, we are therefore exploring the range of works within this class, which can enhance our understanding of its properties.

Besides the formal benefits offered by describing a style in an algorithmic form, this also serves to remove any hidden selective bias within the application of these procedures. It is distinctly possible that artists fail to follow an obvious pathway in some creative map due to our tendency to automatically follow another normative path, as trodden by previous artists. If our model is constructed at a sufficiently low level, such biases would be removed – though care would have to be taken not to encode such a bias within the ruleset itself.

We can also create conjectural models based on emergent cognitive properties of music perception, such as Woolhouse’s model of tonal attraction within interval cycles (Woolhouse, 2009). Rather than construct a descriptive system through stylistic analysis, this approach searches for underlying sensory causes *behind* traditional systems of musical composition – the systems beneath the systems. Such
models allow us to reflect on the meta-reasonings behind whole classes of compositional style, such as the Western diatonic tradition.

We can likewise develop our insight into wider cognitive processes through computational simulation. Tresset and Leymarie’s *Aikon-II* creates facial sketches by observing the subject’s salient features and drawing with a mechanical plotter on paper, visually perceiving the sketch as it draws. The project aims towards gaining an understanding of this feedback process by physically implementing it, and in doing so illuminating any nooks and crannies that are not exposed by theoretical contemplation.

Each of the above approaches can effectively be seen as applied cultural studies, serving to illuminate historical and social tendencies on a broad scale. In homage to Boden’s distinction between historical H-creativity and P-creativity, we will describe this practice as *H-introspection*. Its counterpart is personal *P-introspection*, which applies to the class of tools used to reflect and understand a single artist’s creative acts.

A prime example of P-introspection is Pachet’s Continuator (Pachet, 2003), which uses a Markov model to reflect a player’s performance style through its statistical properties. Another example is the jam2jam-av media performance system, where performers control parameters of generative processes to manipulate musical works in various popular music styles and video images from recorded or live video input (Brown, 2010). In the jam2jam-av system a performer is creating music scaffolded by the generative system and, in addition, the collaborative features of the system allow for riche ensemble experiences. The approach taken by the Continuator and jam2jam-av are in line with Laurie Spiegel’s suggestion in “Manipulations of Musical Patterns”, that suggests that a general practice of ‘extrapolation’, describing it as the “[e]xtension beyond that which already exists in such a way as to preserve continuity with it, to project from it…” (Spiegel, 1981). This implies that the statistical (high-level) properties of a style are maintained, whilst creating new works, “projecting” from the original.

Generative music systems have an advantage over acoustic instruments with regard to feedback and reflection in that they operate (sound) automatically enabling the musician to alternate focus between listening and acting, rather than having to always do these concurrently. A system where this is used to advantage is the *jam2jam* software (Dillon, 2006) developed for online audiovisual performance in educational settings. In jam2jam the generative music is controlled by performers who adjust various parameters including, density, pitch range, tempo, note duration and so on. The educational value of the interactivity is enhanced by the ability of users to pause interactions in order to listen carefully to the music, then make an adjustment and pause to listen to the change – all the while the music continues to generate.

### 1.3.6 Time

A defining factor of the feedback loop between human and computational partners is the time taken for feedback to occur – that is, the period that it takes to produce and reflect upon each new act. Generation and reflection operate in a nested hierarchy, over multiple timescales (Figure 1.7), each reflecting qualitatively different parts of the creative process.

We’ll briefly consider the representatives of digital technology within each of these timescale brackets: seconds and milliseconds, hours and minutes, years and months, centuries and decades. Each of these categories clearly bleeds into each other, and so the following should be read as if it were a continuum.

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15 http://sites.google.com/site/aikonproject/
Fig. 1.7 Hierarchy of feedback timescales. Our actions at any point are a cumulative consequence of previous activity and reflection, with such reflection operating over a number of temporal levels.

**Seconds and milliseconds:** On the micro-level, of seconds or less, an improvising musician produces sound events (notes, beats, timbres) and observe their progression and relationship between other notes and the macroscopic structure of the piece in general. An error may be rapidly incorporated (“retrospectively contextualized” (Sawyer, 2006)) into a performance and reclaimed as intentional, if the player possesses sufficient virtuosity.\(^{16}\)

Scores of interactive pieces of software exist with which we can improvise and hone our skills. The likes of George Lewis’ *Voyager* (Lewis, 2000), Michael Young’s *aur(or)a* (2008), and the field of live algorithms in general (see Blackwell, Young and Bown, this volume) play the role of virtual partners, responding rapidly with semi-autonomy.

**Hours and minutes:** On the scale of minutes, we may develop a piece, adding bars to a movement and replaying it to observe its fit within the wider narrative.

Scaling beyond the length of a single piece of music, we have systems such as Pachet’s Continuator (Pachet, 2003), which reflects back the statistical properties of a user’s musical behaviour over the

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\(^{16}\) See Pachet’s discussion of bebop sideslips (this volume) for a more in-depth treatment on how intentional error-like acts can be used to effectively demonstrate virtuosity
length of entire phrases. The reward is that, through listening back to a distorted edition of their original patterns, the player can better understand their own habits by hearing them recontextualised.

Genetic algorithms can be used to apply a similar process of database amplification, though with different means, encoding a population of inputs as virtual gene sequences which can then be spliced, mutated and bred. Applied in interactive composition environments, with a fitness function provided by their human counterpart, this can provide an effective heuristic-based method of exploring a space (Wiggins et al, 1999).

We have also previously asserted that the development of a single work through iterated generation/evaluation is only generally a characteristic of interactive tools. This is not quite accurate. In the case that an artist is able to modify the code of a generative system, a slower feedback loop can occur: the system is allowed to run, perhaps repeatedly, and its output observed (evaluation); based on this observation, the code is modified to alter or enhance the system’s behaviour (generation). A prominent example is AARON, an autonomous drawing system developed by Cohen (1995) over several decades. On a different timescale, this describes the same process as Live Coding (see McLean and Wiggins, this volume).

Years and months: Our personal style may develop with reference to previous works and external stimuli; a visit to a gallery may prompt a radical departure which causes us to rethink our trajectory, or consider it along a new axis.

By matching musical phrases against a large corpus of recordings based on similarity measures, Query-by-Example (Jewell et al, 2010) enables its users to reflect on how their performances have developed over the course of months or years – or relating them to bodies of other musicians’ work. We could imagine such tools entering much more widely into the reflective practice of artists, allowing them to more closely understand their own historical lineage and their position within a wider context, potentially discovering hidden relationships with previously-unknown peers.

Centuries and decades: Over decades, cultural fashions ebb and flow, and likewise over eras. It is this temporal nature of styles which causes many works to fail to be accepted until long after their creator was deceased.

At the timescale of entire eras, we can interrogate historical tendencies through similar technologies to the above, a process we earlier termed H-introspection. Musical models such as those of Cope (Cope, 1996) can be seen as applied musicology, studying cultural movements by encoding them algorithmically and playing out their consequences. This can aid us to better understand the mechanisms underlying these trends, better illuminating the class of valid compositions that can fall within the bounds of (say) a fugue or chorale.

1.3.7 Authorship

Tyrell: “More human than human” is our motto. – (Blade Runner, 1982)

Collaborations with computational systems raise the issue of contribution toward and ownership of outcomes: when we replace parts of the creative process with an automated system, are we somehow dehumanising the resulting art object? Secondly, if such a system has been produced by another software designer, are we being invisibly driven by the tacit strategies and methods that they have tacitly encoded into the tool? Finally, is it even possible to produce ‘creative’ tools, and does it matter?
The ‘inhuman’ argument

If accept that the output of a human-machine symbiosis will exhibit characteristics of both, it is frequently argued that we are introducing something (unfavourably) inhuman to a realm that is quintessentially human. At least as early as 1987, Charles Ames describes a “virulent” (Ames, 1987, p1) resistance to the uptake of computer-aided composition on this basis.

We suggest that there are actually three underlying roots to this objection:

• that we are (knowingly or otherwise) cheating, by letting the tools do the work;
• that we are (presumably unknowingly) being directed by our tools into particular modes of operation;
• that recourse to reason alone has no place in musical composition in any case, a realm which should be driven by intuition, feeling, narrative, suffering, or other non-algorithmic concerns

The last of these objections has been somewhat defunct in the world of avant-garde composition since Serialism or before. Barbaud (Ames, 1987) responds with an elegant rejoinder:

“Music is generally called ‘human’ when it considers temporary or inherent tendencies of the mind, of part or all of a composer’s personality. Such music is based on feeling and since it turns its back, in a sense, on pure knowledge, it might rather be called ‘inhuman’, for it celebrates what we have in common with all the animals rather than with what is individual to man: his reason. Algorithmic music is thus ‘inhuman’ only in one sense of the word, it is ‘human’ in as much as it is the product of rational beings.” (Ames, 1987, p173)

Similarly, in Nietzsche’s comment on the typewriter “working on our thoughts”, we are tempted to detect a certain pejorative tone in his voice: surrendering parts of our agency to technological devices, so the argument might go, means diluting our creative purity through the hidden bias effects of our supposedly passive tools.

Whether we prioritise intellectual or emotive forces, the acceptance of Gell’s (1998) thesis negates such oppositions by arguing that all components of the creative process exert some agency: we should not be afraid of The degree of such agency is not really of a concern; the networked nature of a creative ecosystem inevitably involves some conflict and resolution, whether conscious or otherwise, and the only concern is the status of the resultant art object itself.

“...in truth, in literature, in science and in art, there are, and can be, few, if any, things, which in an abstract sense, are strictly new and original throughout. Every book in literature, science and art, borrows, and must necessarily borrow, and use much which was well known and used before.” 17

No art production takes place in a vacuum, and is inherently made up of a nexus of eclectic forces, from the selection on instruments to the surroundings in which we develop our work. On the contrary, hermetically sealing our work within an isolation chamber would serve to starve it of the oxygen that it requires to breathe and catch alight.

The fear of technological control over our activities is deeply embedded in our culture. Themes such as these are pervasive in literature and film, from the 19th-century uncanny of Hoffman’s The Sand-Man to the dystopias of 1984, the Borg species of Star Trek TV and the androids of Blade Runner. The ubiquity of networked agencies such as Web recommender systems, however, is surely beginning to allay these concerns in the public eye.

17 Emerson v. Davies, 8 F.Cas. 615, 619 (No. 4,436) (CCD Mass. 1845)
The ‘invisible hand’ argument

Like other tools, the design and development of generative art software locks in aspects of the maker’s aesthetic judgment. When developing a tool which reflects a given process, the maker implicitly make certain decisions in the implementation, style, and scale of application. When we are incorporating general-purpose algorithmic tools into our flow, therefore, the pertinence of this kind of argument rears its head in a different form: are we, in actually, incorporating another person’s artistic work into our own?

Our view is that all creative work is linked closely to its predecessors and the field in which it is located Bown (2009). Insofar as we are taking a system and moulding it to our own goals and ends, adapting the frameworks of a third party are no more invidious than reading a magazine or visiting an exhibition in search of inspiration. Whether technological or conceptual, the raw material of ideas exists to be rebuilt, remixed and extended.

The ‘creative vitalism’ argument

As we have seen previously, the objection to the idea that a computer can perform creative acts is deeply embedded in society. Noticing the level of emotive reactions to Cope’s EMI computational composition system, Dennett comments:

> It is apparently not crass, philistine, obscene ... to declare that all the first-order products of the tree of life—the birds and bees and the spiders and the beavers—are designed and created by such algorithmic processes, but outrageous to consider the hypothesis that creations of human genius might themselves be products of such algorithmic processes. (Dennett, 2001, p284)

Prior to the 19th century, it was obvious to zoologists that the natural world could only exhibit its fantastic, interlocking adaptations by the hand of a designer. That a proposition is “obvious”, however, does not imply that it is true. The belief that the works of nature exceed the capacity of algorithmic processes is a failure of reasoning by analogy: nature appears to demonstrate the complexity of humankind’s designership, and we have no better explanation, so we posit the existence of a superhuman designer. Like Occam’s Razor, this kind of fuzzy reasoning is useful as a rule of thumb, in the absence of a greater body of evidence, but is highly susceptible to the failings of human intuition.

Alongside Dennett and Boden (1990), we believe that the same can be said of creativity. Through the processes at play in artistic creation are surely complex beyond comprehension in their entirety, that is not to say that they cannot be fundamentally algorithmic in nature. Given that anything that can be algorithmically formulated can then be computed, it does not seem inconceivable that, in some distant future, genuinely creative digital devices will exist.

However, we do not believe that this is critical to the kind of tools that make up creative partnerships. Insofar as the creative acts are a result of both computer and human behaviours, the fundamentally important point is that the two together should exhibit some enhanced creativity. Rather than asking the question, “Can technology be creative?”, the question can be formulated as “Can we be more creative through technology?”
1.3.8 Value

During the early stages of an emergent media or technology, artworks often focus on the materiality of the medium itself. Take, for example, video art, sound sampling, and computer art. Over the embryonic years of each of these movements, many of the seminal works are those which place their medium at the forefront: Nam June Paik’s distorted video signals highlighted the invisible ether of broadcast TV transmission; Christian Marclay’s turntablism sonified the physical substrate of the wax record; Manfred Mohr’s algorithmic drawings demonstrated the systematic, infinitely reproducible nature of computation.

These nascent experiments are undoubtedly a consequence of the exploratory and critical roles that art can play, acting as a speculum into the technology’s intrinsic qualities. Subsequently, when a technology has been fully assimilated into society, it becomes a channel to convey other messages or perform other functions.

We see the same thing happening with computer-aided composition. Early practitioners such as Hiller and Isaacson (1958) and Xenakis (2001) foregrounded the formalised, computational nature of their compositions, explicitly presenting the work as being the result of automated systems. In doing so, this awareness became a part of the compositions’ wider conceptual makeup: not just a piece of music, but a product of formal structures and mechanisms.

With the increasing maturity of such methods, the application of algorithms in composition has started to become more comfortably integrated with the rest of the cultural landscape. It is now incumbent on the critic to judge such hybrid human-computer works against the normal value scheme of creative works: responding to aspects of cultural fit, social appropriateness, social usefulness, and beauty.

By incorporating generative processes into a feedback loop over which we then exercise selective control, one can effectively bypass the bulk of the arguments against the inhuman or uncontrollable nature of computational creativity: it is still the artist that exercises the decisive decision-making. For all the conceptual difficulty in realigning our technological understanding with our aesthetic past, the degree and complexity of reflection, development and conceptual weight are arguably all the greater.

As already mentioned, a simplistic view of the human-computer creative partnership has the computer generating material and the human judging it, the reality in most systems is more complex. The degree to which the computational system or the human filters the results depends on the design of the system and/or the intent of the artists. Take for example the fairly hands-off approach (procedural interaction) of Iannis Xenakis with his Gendyn system which was used to create the Gendy 3 composition by generating complete works using hand crafted program settings. The final work was but one iteration selected by the composer. On the other hand, there is the GenJam system by Al Biles that performs quite autonomously, improvising jazz solos created by a genetic algorithm and a data base of human performed solos. In GenJam the user’s ‘control’ consists of playing solos that the system analyses and combines with other contextual musical information, including harmony and metre, to generate its own solos.

Even though both these systems differ with regard to human filtering of the results, they both assume a considerable degree of autonomy over the generation of material. Generative systems with this degree of autonomy are often designed with a particular stylistic outcomes in mind in order to ensure that outputs fall within desired aesthetic boundaries. Other systems, such as Nodal and Emily Howell, are more interactive and require the human to make many more frequent and often quite detailed decisions that guide the generative process. This approach can typically allow for a broader range of stylistic results because of the continual human guidance that is a check against undesirable output.
Regardless of the interaction and division of responsibility during the creation process, once music is completed by a human and generative system partnership, its value is judged like any other music by its audience appeal; whoever the audience is and however value may be defined by them.
1.4 In Summary

“Most people who believe that I’m interested in chance don’t realise that I use chance as a discipline. They think I use it as a way of giving up making choices. But my choices consist in choosing what questions to ask.”
– John Cage (Kostelanetz, 1989, p17)

Over the course of this chapter, we have given a theoretical overview of computer-supported composition strategies, in which algorithmic systems serve to augment an artist’s normal creative activity. Generative computational systems have arisen as a new kind of agency within the creative loop, serving to increase novelty and productivity, with the distinct potential to transform creative behaviours even after our interaction with such a system has ended.

It should now be clear that there is no simple dividing line between passive and active tools; whether we explicitly encode autonomous functionality within our software or not, it still has a latent impact on the work that we do. The description, therefore, of “normal” creative activity is a fallacy. Does your normative creativity occur after being locked in a room for a week, or after exposure to a buzzing cultural ecosystem of films, books, shops and media?

Given the capability of these instruments to autonomously generate new creative trajectories on the same plane as their human counterparts, it seems only apt to characterise this relationship as a partnership. In many cases, however, it is likely that the less autonomous end of the spectrum – Absynth’s randomized VST settings, for example – would not typically be considered as having agency at all. Likewise, the tendency of certain production environments to funnel their users into certain modes of engagement is frequently overlooked as an active force within musical creation.

One hope is that the explicit consideration of generative tools may heighten the awareness that such minimal concerns do, in fact, impact on our creative behaviours more than we typically believe. How would the tone of this chapter have differed if it had been written in fountain pen on parchment, rather than plastic keys and a luminous LCD display?

1.4.1 Future Explorations

This research field, as with all of computational creativity, is still in its infancy. Partially due, no doubt, to the objections levelled in Section 1.3.7, these ideas have been gradual in taking hold within the musical world outside of avant-garde and academic composition. Moreover, for a composer to go beyond off-the-shelf tools and begin developing algorithmic approaches alongside their musical development has a major barrier of entry: namely, the technical know-how to do so, or the presence of an engineer-collaborator at hand.

In terms of a wider public perception, the most significant development for the field over the past decade has been a number of significant and high-profile incursions into the mainstream, often mediated through the gaming industry. The likes of Rez, Elektroplankton and Bloom enable casual players to make diverse and accomplished music through simple interfaces, giving a taster of what it may be like to engage with more advanced musical activities. A survey by UK charity Youth Music18 found that 19% of young people playing music games such as Guitar Hero were subsequently encouraged to start playing a musical instrument.

Driven by this enlarged audience, new instruments are emerging which have some characteristics of these novice-friendly devices but with the scope to be used in more advanced, freeform contexts.

18 “Why console-games are bigger than rock ‘n’ roll”:
The Tenori-On, a physical device designed by Toshio Iwai (*Elektroplankton*), is a tactile sequencer with generative capabilities. Alongside attracting praise from untrained players, acting as an entry-level introduction to sequencing notions, the Tenori-On was used by innovative pop musician Björk on a recent tour. It can also be used to control user-created samples and external MIDI devices, eliminating another hidden limitation of many sound toys. With the glass ceiling removed, potential players are now presented with instruments which are as versatile to the virtuoso as they are to the beginner.

### 1.4.2 Final Reflections

We could imagine quite different ways to group together and order these ideas. This format, however, has been brought about by our collective experiences within the field, based on the ideas, theories and questions which frequently emerge from applied use of computer-aided composition. It may well be that, as the field continues into maturity, further experiments will lead us to produce radically new sorts of questions and systemic categories.

Perhaps the single unifying factor which ties together each of these perspectives is that they all encourage us, in different ways, to reflect upon the entirety of creativity itself. To build generative software that operates appropriately in a creative ecosystem, we must secure some understanding of how we interact with our existing partners and tools, and how they interact with us. Likewise, designing new intimate interfaces to creativity means we must more fully understand what it means to develop a close relationship with an instrument, and the conditions necessary for virtuosity and value to arise from this.

Some understanding of the veiled process of creativity is necessary to drive the “productive entanglements” (Clark, 2008) with technology that we are here trying to foster. With luck, these entanglements should serve to reciprocally inform our understanding of creativity, in another culture-scale feedback loop.

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