# Chapter 14
# Generative and Adaptive Creativity: A Unified Approach to Creativity in Nature, Humans and Machines

**Oliver Bown**

**Abstract** Computational creativity is not limited to the study of human-like creativity and forces us to think about creativity as a general process that can be applied wherever new things come into existence. In this chapter I propose that in order to unify various forms of creativity it is necessary to consider a distinction between two types of creativity: generative creativity, in which things are created as the result of a process regardless of their value, and adaptive creativity, in which things are created as adaptive responses by a system to its situation. Whilst individual human creativity is typically of the adaptive form, collectively humans are engaged in processes of generative creativity as well as adaptive creativity. It is helpful to understand human creative behaviour as part of a social process involving these two aspects, and this is relevant to understanding how manmade artefacts can act as creative agents in social networks.

## 14.1 Questions About Creativity

Theories of creativity are so commonly focused on human behaviour that for many researchers there is no need to address notions of creativity outside of the frame of reference of human psychology. In the disciplines centred around psychology this is appropriate. As part of the cognitive sciences, it is also reasonable for artificial intelligence (AI) to stick to this delimitation of creativity as an activity. The study of computational creativity, as demonstrated by the range of contributions to this book, is very different in that it poses scenarios which provoke us to view creativity in significantly more varied terms—scenarios, for example, where the computer acts as a generator of variation, heavily mediated by its user.

To this end, human psychology is a limited reference point. Computational creativity is the study of creativity by any computational means, not necessarily those modelled on human minds, or even on human goals, and as such the discipline takes on the challenge of developing a more fundamental understanding of what it means

O. Bown (✉)
Design Lab, Faculty of Architecture, Design and Planning, University of Sydney, Sydney, NSW 2006, Australia
e-mail: ollie@icarus.nu

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for something to create, and of where and when a creative process has occurred. In taking this broad stance on creativity, computational creativity necessarily concerns itself with acts of creation wherever they occur, not just in humans. We require a broader view of creativity as the process of creating novel things, not limited to a suite of psychological capacities. This richer notion of creativity emerges alongside practical innovations in our research and feeds back into informing an understanding of creativity in humans and elsewhere.

The most prevalent example of non-human creativity is the Earth's history of natural evolution,[1] associated with an early sense of the term "creativity", as in *creationism*, the exclusive remit of God (Williams 1983). Whether through Nature or God, the biological world, including us, stands as evidence of dramatic creativity.

In a broader sense still, computers routinely, mundanely, create things. An elementary type of creativity can be achieved by the rapid, random production of varieties from a set of generative rules. In the simplest case, this can be a set of parameter specifications that can be assigned different values to produce different outputs. These things are creations: new entities that would not otherwise have existed. This is creativity with a crucial caveat: somebody or something *else* has to come up with the generative rules. A pragmatic choice for very simple experiments in computational creativity, for example, is the spirograph, in which a set of gear ratios can be used to define a space of non-trivial visual patterns (Saunders 2001). Obviously, all you get from such a system is spirographs, pretty patterns with a minuscule potential to deliver something truly surprising. Equally, one could use a computer to begin to search the vast parameter space of all 500 by 500 pixel 24-bit colour images, an example discussed by McCormack (2008). One could proffer that there are still phenomenal 500 by 500 pixel colour images yet to be seen by a human eye, but the space to search is so vast that any naïve search has no certainty of finding them. With generative techniques, new things *can* be created that have never been created before, trivial though this may seem. This "generative creativity", in its simplest form, is a particularly weak form of creativity, but by such accounts it still seems to be creativity.

These examples of non-human creativity are, in quite different ways, distinct from the human cognitive activity associated with *being creative*, but they are both important to the study of computational creativity. This chapter uses the terms generative and adaptive creativity to help unify these diverse manifestations of the act of creating things into a common theory.

The structure of this chapter is as follows: I will explain the meaning of generative and adaptive creativity in the following section. In Sect. 14.3, I will discuss the relevance of generative and adaptive creativity to current research in computational creativity. I will then consider social systems firstly as creative systems that are more than just the sum of human creative acts, and then as both adaptively creative units

[1]Discussions on this topic can be found in the chapters by Cariani (Chap. 15) and McCormack (Chap. 2) in this book, in earlier work in computational creativity by, for example, Bentley (1999b), Perkins (1996) and Thornton (2007), and in more remote areas of study such as Bergson (1998) and de Landa (1991).

and as generatively creative units. I will consider examples from computational creativity research of modelling social creative systems. I will also consider individual humans as exhibiting generative as well as adaptive creativity. Finally, I will return to computational creativity (Sect. 14.4) and consider how ideas of generative and adaptive creativity can be used to support developments in computational creativity research.

## 14.2 Generative and Adaptive Creativity

From the broad perspective of poiesis—of how things come about—all the patterns, structures and behaviours that exist in the world can be taken as evidence of creativity. This jars with the traditional psychological view of creativity, and implies a distinction between two varieties, which I will refer to in this chapter as *generative* and *adaptive*. Generative creativity takes an indifferent approach to the problem of value, it is value-free creativity. In generative creativity, things are not created for a purpose. Things *can* come into existence without being created for their value.

The mechanical variation of the spirograph discussed above may be the least ambiguous, albeit banal, example of generative creativity. Natural evolution is a more impressive example, but more contentious because the relationship between nature's creative processes and the production of value is complex. Natural evolution provides means for lineages of organisms to adapt to their environments, but it is also responsible for producing both evolutionary challenges and their evolutionary solutions together in tandem, in the absence of an ultimate goal. Peacocks' tails are useful to peacocks, and the advancement of their progeny, because they are attractive to peahens, but *this utility is there for the genetic lineages of peacocks and peahens, it does not serve the process of evolution that produced them.*

Value (survival value, the value of sexual attractiveness) is part of the equation that feeds these evolutionary processes, but the creative processes that produced the peacock's tail is not, in this author's opinion, an adaptively creative process, as I will define it below.

This view may yet be mistaken: Gaia theory, for example, implies that there is a general process of improvement driven by evolution (Lovelock 1979). I may also be underselling the true value of peacocks' tails, in light of the handicap principle (Zahavi 1975) or honest signalling theory (Owings and Morton 1998). With these and other complex issues in evolutionary theory in mind, readers may understandably take the opposite view that natural evolution is not indifferent to value and is thus adaptively creative, as defined below. Indeed, the definitions below do not preclude the possibility of evolutionary adaptation providing examples of adaptive creativity. The view offered here, though, is that generative creativity is the more predominant aspect of natural evolution: whilst valuable functions are established during the evolutionary process, the subject (and beneficiary) of the value—the peacock for example—is not the creative agent behind the trait, and the process that, if anything, is the creative agent—an abstract evolutionary mechanism—is a non-entity as far as "benefits" are concerned.

Put more bluntly, a once barren planet now teems with life. There is no function that this life was brought into existence to perform. This is generative creativity.

Adaptive creativity is concerned with the process of creating things as an adaptive behaviour, perhaps one of a suite of adaptive behaviours, exhibited by a system (person, animal, computer, social group, etc.). The least ambiguous example of adaptive creativity would be everyday problem solving, where an individual finds a new way to directly improve their life. Basic problem solving is widely observed in the animal kingdom; a plausible explanation for this is that a suite of cognitive faculties evolved through selective advantage. Through networks of exchange, humans can also benefit from inventions that are not directly useful to them. The arts, with which this chapter is primarily concerned, are more controversial in this respect: many would question the relationship between art and adaptive behaviour. But the less controversial association between art and value is reason enough to place artistic creativity in this category. It would seem fair to say that artists generally benefit from the artworks they produce, even if we are not sure why. Creating something of value, albeit in a convoluted socially constructed context, is, I will assume, an adaptive behaviour.

There is a lot to unpack from these preliminary remarks, which I will do throughout this chapter. To begin, generative creativity and adaptive creativity will be defined as follows:

- *Generative Creativity*: an instance of a system creating new patterns or behaviours regardless of the benefit to that system. There is an explanation for the creative outcome, but not a reason.
- *Adaptive Creativity*: an instance of a system creating new patterns or behaviours to the benefit of that system. The creative outcome can be explained in terms of its ability to satisfy a function.

Adaptive creativity is here intended to describe the familiar understanding of human creativity as a cognitive capacity. Generative creativity is its more mysterious counterpart, and helps extend the scope of creativity to cover a greater set of creations. Although this duality could be represented simply as novelty with or without value, the terms are taken to emphasise two essentially different characters that creativity can assume.

Generative creativity may seem like a distraction from the problems of understanding human creativity, and of establishing human-like creativity in computational systems. The main aim of this chapter is to argue that the duality of generative and adaptive creativity is instead highly relevant to our understanding of human creativity, offering a framework with which to understand individual and distributed social creative processes in a common extensible and future-proof way. The generative/adaptive divide is argued to be as useful as the human/non-human divide, and is different in significant ways. This picks up the cause of emphasising how important the social dimensions of human creativity are, following socially-oriented theories such as those of Csikszentmihalyi (1999), but since this cause is already well established, the more relevant goal is a framework that unifies these elements.

I have briefly discussed natural evolution above, and its ambiguous relationship to adaptive creativity. A similar discussion will be applied to culture in greater depth.

In the following sections, I will discuss how the notions of generative and adaptive creativity apply in various instances associated with human social behaviour. In doing so I will draw on concepts from the social sciences which I believe can enrich the conceptual foundations of computational creativity. The discussion is geared towards arts-based computational creativity, but will draw from scenarios outside of the arts.

## 14.3 Generative and Adaptive Creativity in the Arts, in Humans, Human Groups and in Silico

The generative/adaptive framework can be applied to the way we characterise the creativity of artificial systems in the poorly understood domain of human artistic behaviour. Despite some clear achievements in arts-based computational creativity, success has been marred by the challenges of evaluating the products of creative systems in a meaningful way (Pearce and Wiggins 2001, Greenfield 2006, McCormack 2008). We struggle to disambiguate the creative input of the system's designer from the creative output of the system itself (Greenfield 2006), and we also struggle to establish valid contexts for either subjective or objective judgement of creative outputs. This ambiguity has made arts-based computational creativity particularly resistant to the bootstrapping of future developments from previous success. It is hard to make informed decisions about the relative virtues of different computational methods (genetic algorithms, neural networks, etc.) because arts-based computational creativity research lives mainly in the lab, with many additional steps required to get from this to the real field of human artistic activity. This suggests the need for a richer characterisation of creativity, including the role of social dynamics as a creative system, as well as the role of creative individuals within that system.

Above all, in labs, goals are implicitly defined for arts-based computationally creative systems which have ill-defined parallels in the world of human artistic goals. A person has a flexible and creative relationship with the value of the cultural artefacts he creates and is surrounded by, for example by being free *not* to be artistically creative. As currently conceived, an arts-based computationally creative system is, by contrast, a tool with a function assigned to it. It can only be adaptively creative within the limits imposed by its given function (it must make art). Functionality is a desirable property of all manmade systems. An artificial creative system is expected to do more than generative creativity (an end in itself), because it is required to produce outputs which are not just novel but have some externally established value. As such, arts-based computationally creative systems target a novel niche, in terms of their social embeddedness, which is yet to be clearly characterised. There is a need to establish a discourse that properly recognises this niche.

What, then, is the nature of natural creative systems in terms of function? To determine what kind of status a creative tool could take, it is important to look at human creativity not only at the individual level: individuals in isolation cannot provide us with an understanding of the creative nature of the arts because a complete understanding involves identifying how value is generated within a social system (Csikszentmihalyi 1996). I will expand this point with reference to relevant perspectives in the social sciences, as it is an important prerequisite for considering how social systems and individuals can be generatively and adaptively creative.

### *14.3.1 The Creativity of Social Systems Is More than the Sum of Individual Creative Acts*

Our creative capabilities are contingent on the objects and infrastructure available to us, which help us achieve individual goals. One way to look at this is, as Clark (2003) does, in terms of the mind being *extended* to a distributed system with an embodied brain at the centre, and surrounded by various other tools, from digits to digital computers. We can even step away from the centrality of human brains altogether and consider social complexes as distributed systems involving more or less cognitive elements. Latour (1993) considers various such complexes as *actor networks*, arguing that what we think of as agency needs to be a flexible concept, as applicable to such networks as to individuals under the right circumstances.

Gell (1998), proposing an anthropology of art, likewise steps away from the centrality of human action by designating primary and secondary forms of agency. Artefacts are clearly not agents in the sense that people are, that is, *primary agents*, but they can be granted a form of agency, *secondary agency*, to account for the effect they have on people in interaction. Gell argues that we need this category of secondary agency, which at first seems counterintuitive, in order to fully account for the networks of interaction that underpin systems of art. Artworks, he argues, abduct agency from their makers, extended to new social interactions where they must necessarily be understood as independent. This idea of art as an extension of influence beyond the direct action of the individual is also emphasised by Coe (2003) as key to understanding the extent of kin-group cohesion in human societies: by extending influence through time, such as through decorative styles, an ancestor can establish strong ties between larger groups of descendants than otherwise would be possible.

It is hard to be precise about exactly what is meant by artworks and artefacts here. For example, decorative styles are in a sense just concepts, in that they can only be reproduced through individual cognition, and the same is true of artefacts if they are to be reproduced and modified in continued lineages (Sperber 2000)—a situation that would radically change with self-reproducing machines. But artefacts are concepts built around a physical realisation, which is itself a carrier for the concept. That is, objects participate in the collective process of remembering and learning that allow a culture to persevere and evolve over time.

Artworks can take on a slightly different status. They are typically defined as unreproducable, even if they are effectively reproduced in many ways (Gell 1998). Like many other artefacts involved in social interaction, such as telephones and social networking tools, they act to shape a distributed creative process. These may be the products of individual human invention, but they do not simply get added to a growing stockpile of passive resources, but instead join the process as secondary agents (Gell 1998). Put another way, when culture is seen as a creative system, it is inclusive of all of these objects, which contribute functionally to the system, just as the distributed modular mechanisms of the human brain may be required to be in place for individual creative cognition to function. Similarly, a memetic view of culture sees ideas, concepts, designs and so on as not just cumulative but effective, a new form of evolutionary *raison d'être* added to the biological world (Dawkins 1976). These "memes" are understood as having an emergent teleological functionality: brains evolved under selective pressures, and memes were thus unleashed. But what are memes for? The answer: they are only for memes. Sperber (2007) provides a strong argument for rejecting memes, but promotes the idea of distinguishing between a designated function (a function we ascribe to something) and a teleofunction (a function of something in an evolutionary sense, in service of its own survival).

Just as neuroscientists care about the behaviour of synapses as much as they do neurons, a theory of social creativity depends on the functional importance of both primary and secondary agents. We can view any digital arts tool as a secondary agent, but arts-based computational creativity holds the promise of introducing secondary agents that are richly interactive, and as such creatively potent (if not adaptively creative), encroaching on the territory of primary agents. Arts-based computational creativity researchers, by definition, study the possibility of artefacts with agency, and in doing so reveal a gradient of agency rather than a categorical division.

The *Interactive Genetic Algorithm* (IGA) (Dawkins 1986), for example, is an artificial evolutionary system in which a user selectively "breeds" aesthetic artefacts of some sort (see Takagi 2001 for a survey), or manipulates an evolutionary outcome via a user-defined fitness function (e.g. Sims 1994, Bentley 1999a). The IGA can only possibly achieve adaptive creativity by being coupled with a human user, in a generate-and-test cycle. However, it allows the user to explore new patterns or behaviours beyond those he would have devised using imagination or existing forms of experimentation (Bentley 1999b). As such, it is not autonomous, and yet it is active and participatory, grounded in an external system of value through a human user.

Researchers in IGAs continue to struggle to find powerful genetic representations of aesthetic patterns and behaviour that could lead to interesting creative discovery (e.g. Stanley and Miikkulainen 2004). But more recently, IGAs have also be used to couple multiple users together in a shared distributed search (Secretan et al. 2008). Whilst an individual approach views IGAs as creative tools that extend individual cognition, as in the extended mind model, the distributed notion of an IGA embodies a social view in which no one mind can be seen as the centre of an artificially extended system. Instead, minds and machines form a heterogeneous network of interaction, forcing us to view this hybrid human and artificial evolutionary system on a social level. In this and other areas, arts-based computational creativity is well-poised to bootstrap its future development on the emergence of social computing, which presents a training and evaluation environment on the scale of a real human social system.

### *14.3.2 Social Systems Can Exhibit Both Generative and Adaptive Creativity*

To be adaptively creative, social systems must be shown to form coherent units to which creativity is beneficial. Society contains many structures that naturally appear to us as unified wholes, such as families, organisations and nations, even when the individual members of these groups might be interchangeable. In certain cases, these unities act with intention and planning and can be creative in a sense that is more than simply an accumulation of individual creative acts, through the formation of structures which incentivise, intensify and exploit individual creativity. In other circumstances, overlapping with these adaptive scenarios, social groups lack the shared intention required to view them as adaptive units, but nevertheless act as powerful generative systems. In such cases it is not possible to view the system's creativity as serving specific adaptive goals at the level that they are generated. For the groups concerned, treated as units, the system's creativity may be counter-productive, even if it involves adaptive creativity at the individual level. From an evolutionary perspective, this position is no surprise: we do not generally expect groups to sustain collective adaptive behaviour, as they can be easily undermined by selfish individuals exploiting the adaptive properties of the group (Wilson 1975). The important point for defining generative creativity is that there are properties of the system that are necessary for an understanding of how new patterns and behaviours emerge, that are not adaptations by the group, and that go beyond the accumulation of individual adaptive creativity.

#### 14.3.2.1 The Causes and Effects of Culture

As this implies, understanding adaptive and generative creativity in social systems depends on understanding the dynamics of cooperation and competition in human social behaviour. A simple way that adaptive and generative creativity can be seen to be linked through culture is through the following evolutionary explanation:

1. Cultural behaviour arose due to specific evolutionary adaptations in individuals such as the ability to imitate successful behaviour, to understand others' goals, to manipulate behaviour and to be adaptively creative (Barkow et al. 1992);
2. This leads to:
   a. The formation of structured adaptive social units stemming originally from family groups and simple local alliances, in which a collective interest can become established (Fisher 1958, Axelrod 1997, Maynard Smith and Szathmáry 1995, Hamilton 1963); and
   b. The cultural conditions for less cooperative interaction which can have runaway generative effects, especially under the constraints of structured adaptive social units (Boyd and Richerson 1985, Blackmore 1999).

As with the definitions of generative and adaptive creativity, we can try out statements (2a) and (2b) against specific instances of social behaviour. This theoretical outline is most clearly conveyed in Boyd and Richerson's influential body of work (Boyd and Richerson 1985), in which they propose that much cultural behaviour can be thought of as "baggage", unexpected but tolerable spin-offs from the powerful success of applying simple frugal heuristics for social learning, fitting the scenario of (2b). The same pattern is expressed by a number of theorists who share the conviction that an evolutionary explanation does not mean simply seeking a function for each trait and behaviour of the human individual. For example, Pinker (1998) explains music as evolutionary cheesecake: something that is pleasurable and compelling not because it is adaptively useful in itself, but because it combines a number of existing adaptive traits. Being creative, he proposes, we have found new ways to excite the senses, and continue to do so. Thus, controversially, music joins more obviously maladaptive and sinister "inventions", such as drugs and pornography.

At the same time, Boyd and Richerson (1985) posit that social learning can alter individual human evolutionary trajectories by coordinating and homogenising certain aspects of behaviour across a group, counteracting the effect of disruptive selfish behaviour, and explaining how groups of individuals can consolidate collective interests over evolutionary time. This fits the scenario in (2a). Others have explored how the social structures enabled by more complex social behaviours can lead to the evolution of increasingly group-cooperative behaviour. For example, Hagen and Bryant (2003) explain music as a means for groups to demonstrate the strength of their coalition as a fighting unit. The basis for their theory is that since practising complex coordinated behaviour such as dance and music takes time and individual commitment, a well-coordinated performance is a clear—or *honest* in evolutionary terms—indicator of how cohesive the group is. Honest indicators of fighting strength and commitment, like a dog's growl, can serve both parties weighing up their chances in a fight, by indicating the likely outcome through indisputable displays (Zahavi 1975, Krebs and Dawkins 1984, Owings and Morton 1998).

A growing body of research into the relationship between music, early socialisation (such as mother-infant interaction) and group cohesion supports this basic thrust (Dissanayake 2000, Cross 2006, Parncutt 2009, Richman 2001, Merker 2001, Brown 2007), although it may be manifest in alternative ways. Such theories are evolutionarily plausible despite being seemingly "group-selectionist", because they can be understood in terms of kin-selection and honest signalling taken to increasingly extended and complex social structures (e.g. Brown 2007, Parncutt 2009). As Dunbar (1998) has demonstrated, vocal communication in humans may form a natural extension to the kinds of honest signalling of allegiance found amongst primates, correlating with both group size and brain size. These theories are also commensurate with the widely consistent observations of anthropologists that the representation of social structure, such as in totem groups and myths, is a universal cultural preoccupation (Lévi-Strauss 1971, Coe 2003).

#### 14.3.2.2 Social Groups as Adaptive Units

Organised and cohesive social groups frequently coordinate and structure individual creative behaviour, and increasingly so in more complex societies, which are able to incentivise, intensify and exploit creative discovery through the distribution of resources and power (Csikszentmihalyi 1996). Consider an illustrative example from Sobel (1996): at the height of colonial competition a grand challenge for naval science was the discovery of a technique to determine longitude at sea. Whilst latitude could be determined entirely from the height of stars above the horizon, longitude could only be reckoned in this way relative to the time of day, which could not be known accurately using existing clocks. Errors in longitude estimation could be disastrous, costing time, money and lives, and the demand for a solution intensified as the problem of longitude became increasingly pivotal to naval supremacy. A substantial prize was offered by the British government, and the prize stood for many years before being claimed. The solution came from a lone, self-taught clockmaker, John Harrison, who made numerous small innovations to improve clock accuracy.

Of interest here is not only John Harrison himself but the great efforts invested by his competitors in pursuit of the prize money. Some had far flung ideas, others pursued fanciful but reasonable alternatives, others still were clockmakers like Harrison himself, pursuing different techniques. More serious competition came in the form of an astronomical solution which required knowing the future trajectory of the moon for years to come. Together, these disparate groups "collaborated through competition" to discover the solution to the problem of longitude, naturally dividing their efforts between different domains, and giving each other clear ground to occupy a certain region of the search space.

Here, within-group competition was artificially driven by a prize, constrained by certain socially imposed factors: the prize money established a common goal, and awareness of existing research drove specific innovators down divergent pathways, and incentivised outsiders to bring their skills to the challenge. The prize encouraged outsiders with far-flung interests to put effort into a solution, and at no expense to the government. This underlines the difference between a prize, for which only one innovator from the domain gains, and a series of grants for research. The former is indifferent to effort, excellence or even potential and is motivated by uncertainty about where a winning solution might turn up. Like the fitness function in an optimisation algorithm, it cares only for success, and it has a clear means for determining success. The latter invests in potential and uses effort and excellence as indicators of likely success. Both forms of finance played a role in establishing the solution, since Harrison actually received occasional grants from the Board of Longitude to fund his gradual development, indicating that they has some confidence in a clock-based solution. Harrison was once a maverick outsider, drawn by the prize. Through his early promising efforts he became a refined and trusted investigator, deserving of further funding.

Only through the constant jostle of shifting social interaction can this outcome be explained. Historical examples of social creativity such as the Longitude Prize have helped to build our modern world of research councils, music industry major labels and venture capitalism, for example by demonstrating the powerful creative potential of open markets. Harrison, an unlikely outsider to the challenge, was first motivated, then identified as having a chance, then allowed to flourish. The prize also had its losers, whose time and perhaps great talent went unrewarded, wasted in pursuit of a prize they didn't win. Their attempts at individual adaptive creativity may have failed, and yet inadvertently they contributed to the adaptive creativity of some larger social group with their various negative results. That is not to say they were duped or that they acted maladaptively. Many modern professionals, such as architects and academics, compete against challenging odds to get coveted funding or commissions. Most find they can reapply their efforts elsewhere, which is in itself a creative skill.

It seems plausible that this kind of competitive dynamic also has an inherently self-maintaining structure: those who are successful, and therefore able to impose greater influence on future generations, may behave in such as way as to reinforce the principles of competition in which they were successful. A prize winner may speak in later years of the great social value of the prize. Those who are successful at working their way up in organisations might be likely to favour the structures that led to their success, and may try to consolidate them.

In other cases, the emergence of new social structures or the technologies that underpin new social arrangements, innovated by various means, may act to the detriment of individuals. An example is the innovation of agriculture as presented by Diamond (1992), which was a successful social organisation because it enabled the formation of larger centralised social groups with a greater division of labour, despite worsening the diet of the average individual.

#### 14.3.2.3 Social Groups as Non-adaptive Generators

According to the idea that cultural behaviour attracts baggage—runaway cultural patterns of behaviour (Boyd and Richerson 1985)—the same mechanisms of incentivisation can occur in generative creative processes, that is, in situations in which the collective system is not behaving adaptively in sight of a goal. For example, whether or not music or the arts are valuable to social groups, individuals adaptively pursue goals as musicians or artists (Huron 2001 provides a non-Western example), and in doing so change the world of arts as a whole over time. The change itself need not necessarily be the result of individual innovation. Although we have a taste for novelty, artistic behaviour is also constrained by conservative forces: musicians and artists are compelled to work within a style, and success is by no means proportional to the degree of novelty of the producer (Boden 1990, Csikszentmihalyi 1996, Martindale 1990). Thus it cannot be taken as given that the explanation for variation in the arts comes down only to individual creative innovation.

A musical fad, for example, is characterised by the explosion of interest in a radical new style. When that explosion occurs, individuals from diverse backgrounds may redirect the skills they have nurtured elsewhere to this domain (a derogatory expression for which is "jumping on the bandwagon"). This results in novel music, but it is the cultural process—the rapid spread of a fad through a population—that actually underlies the processes of exploration and combination that contribute to a creative outcome, not the individual creative capacities of individuals to innovate successful solutions to an artistic goal. Individuals may actually be acting not innovatively, but identically and predictably: applying existing habits and background knowledge to a new domain, and engaging in something of a lottery over the future direction of musical style. Indeed, musical change over decades may be less to do with innovation than to do with waves of individuals, generations, restructuring musical relevance according to their own world view, involving a combination of group collaboration and within-group and between-group competition. Hargreaves (1986) considers such fashion cycles in the social psychology of music. Fads offer an indication of how creative change at the social level can occur as a combinatoric process built on gradual mutation and simple individual behaviour, and can only be understood at that level. The negative connotations of a fad as ephemeral and ultimately inconsequential emphasise the generatively creative nature of this process: a fad satisfies no goal at the level on which it occurs, although many individuals may be satisfying individual goals in the making of that process.

The nature of the arts both with respect to adaptive human social behaviour, and as a collective dynamical system, is becoming better understood, but sociologists and anthropologists have struggled with good reason to develop a solid theoretical framework for such processes, and we still have far to go before we can disentangle adaptive and generative aspects of social artistic creativity.

#### 14.3.2.4 Modelling Creativity in Social Systems

Strands of arts-based computational creativity research have focused on generative aspects of social systems and their relationship to individual adaptive creativity. Gero, Sosa and Saunders have explored a large space of social models of design creativity in which individuals collectively define the social conditions in which they both produce and judge creative artefacts (Saunders 2001, Saunders and Gero 2001, Sosa and Gero 2003). Saunders and Gero (2001), for example, demonstrates clique formation through mutual influence and learning of specialised interest, suggesting a generative creative process in which a population of agents spawn novel styles through a group dynamic. Such models often establish the necessary conditions for generative creativity by establishing that what determines fitness is not an external environment but the population itself through a process of feedback (Laland et al. 1999, Bown and Wiggins 2005), a fundamental consideration in evolutionary psychology (Dunbar 1998, Tomasello 1999), and a property of other generatively creative processes in nature, such as sexual selection (Miller 2000) and niche construction (Odling-Smee et al. 2003).

I have adapted such models to an evolutionary context in order to explore the potential influence of generative social dynamics on evolutionary change (Bown 2008). Pinker (1998) uses “evolutionary cheesecake” as a description of music inviting the question of whether such a cultural development might actually become reinforced, and thus biologically locked-in, through evolutionary adaptations: if musical behaviour becomes adaptively beneficial to individuals through its increasing prominence in social life—which is the implication of Pinker’s hypothesis—then we could ask whether humans have even evolved to become more musical under constructed social pressures. The resulting model illustrated that this reinforcement could happen through kin selection exploiting social interaction "games" in which individuals rewarded each other with prestige. According to this model, it isn't even necessary to assume that music appeared at first as a culturally innovated *susceptibility to enchantment* (Bown 2008), since the susceptibility itself could be seen to emerge as a result of the social dynamics.

Such models can in some cases provide a proof-of-concept for mechanisms of evolution and social change. However, they necessarily remain abstract and far removed from attempts to conduct predictive modelling of social dynamics (Gilbert 1993).

### *14.3.3 Individual Humans Can Exhibit Generative and Adaptive Creativity*

It is reasonable to accept the assumption that individual human creativity is strictly of the adaptive type. Darwinian evolutionary theory predicts that as evolved organisms, most of our behaviour is ruthlessly adaptive, at least adapted with respect to some evolutionary environment of the past (Wilson 1975, Dawkins 1976). But there are reasons why a human's behaviour could also fit the description of generative creativity instead. For an individual to be generatively creative, this would mean that they generate and sustain novel patterns or behaviours without any regard to the externally determined value of these patterns or behaviours. If art was only about innovation of artefacts designed to stimulate other people for individual gain, this would be an unlikely pattern of behaviour. But consider art as a multi-faceted cultural complex, involving elements such as identity. In service of an identity, an individual might generatively create effectively arbitrary patterns or behaviour, the value of which then come through association with other properties of the individual.

Coe (2003) proposes visual decoration as a mechanism for identifying the co-descendants of a common ancestor in the traditional small-scale societies of our evolutionary history. Similarly decorated individuals are both common genetic descendants and, more importantly, cultural descendants of an ancestral figure, inheriting and thus preserving styles and art techniques originated by that ancestor. Here, to call the ancestor adaptively creative for successfully innovating a style or technique is misleading, since the value of the style or technique created might only be realised through its role for the group. The style or technique might otherwise be arbitrary. Although the social system maintains the style over the long-term, the individual may well generatively develop styles and techniques according to idiosyncratic methods, and sustain them for some time. Admittedly we may never know the true generative status of individuals, since their creative output is always manifest in social interactive contexts, but introspectively we can all appreciate the generative capacity of the mind at work, producing thoughts in the background without regard for their value. The technique of brainstorming involves the idea of holding back value judgement, so that generative thought processes can operate more freely in the individual, thus shifting the process of value judgement required for adaptive creativity to the collective level.

Generatively created patterns or behaviours can thus be exported to social systems through a process of "creating value". The capacity to create value may itself be an adaptive skill, or a matter of social context or luck: a more influential individual might have more freedom to act generatively than someone trying to fit in; a maternal ancestor might have experienced reproductive success for distinct genetic reasons, which carries the success of their otherwise insignificant cultural behaviour through vertical cultural transmission. Value creation does not necessarily mean "adding value" (as in making the world a better place), but "manipulating value": shifting the social conditions within which other individuals must act. A challenge for arts-based computational creativity is to understand whether "adding value" is at all meaningful: can we make better art through technology? To assume so without evidence would justifiably be viewed as complacency.

Alternative social aspects of the arts such as identity cast into doubt the centrality to arts-based computational creativity of the capacity to evaluate, which is commonly cited as critical in building artificial creative systems. From the perspective of strict adaptive creativity this is less problematic: an individual cannot behave adaptively if it cannot determine the real-world value of its creative produce. But if an individual is able to create value through influence, then the role of evaluation in the creative process should strike a balance with other elements. Evaluation in human artistic behaviour must be understood in the context of value creation, and other aspects of artistic social interaction. We risk turning evaluation into a bottleneck through which we squeeze all artistic interaction. Escaping the narrow focus on assessing aesthetic value, which avoids the need for a social individual that might be capable of exporting or creating value, is an important but challenging direction for arts-based computational creativity: what other dimensions of response, meaning and interaction are needed in computational systems?

## 14.4 Generative and Adaptive Approaches to Arts-Based Computational Creativity

Human-like adaptive creativity is the more traditional goal of arts-based computationally creative systems, but faces the challenge that the embodiment and situatedness of the artificial system is a poor reproduction of that of the human. It also faces the additional challenge of building adaptively creative systems that satisfy the constrained target of "valued" artistic output. Subsequently, some of the more successful examples of computational creativity have been human-system collaborations, such as Harold Cohen and his *AARON* software (McCorduck 1990), or George Lewis and his *Voyager* software (Lewis 2000).

A generative creativity approach seems equally problematic since generative creative systems are not adapted to goals and so cannot perform functions similar to human adaptive creativity. But if artistic creativity in cultural systems and humans involves the kinds of interaction between generative and adaptive processes discussed above, then a useful goal for arts-based computational creativity is to better understand this interaction in models and in experiments with interaction in artistic social behaviour, including studying the role of value as a medium of interaction between different systems. Through this understanding we can find ways to hybridise generative and adaptive creative processes. Two useful avenues of research are as follows.

### *14.4.1 Generative Creative Systems Can Be Externally Useful*

Arthur (2009) describes technology in terms of phenomena: aspects of the world revealed through experimental interaction. In this view, innovation occurs through the exploitation of phenomena in the service of human goals. By revealing new phenomena, generative creative processes make new innovations feasible. We exploit the properties of materials, which can be produced through a generative process of chemical interaction. Cosmological and geological processes have produced numerous useful materials without purpose, and have not produced others. Likewise, although the products of natural evolution can be seen as having evolved to fulfil a purpose, we may exploit those products in ways that have nothing to do with their evolutionary origins: using a bird's feather as a writing implement, for example. Invention goes from feasible to easy to obvious when the generative process not only makes a material but makes it abundant, as in this example. This is often described in terms of the *affordances* offered by some structure. A celebrated form of human creativity involves re-appropriating existing things for new uses. The fact that things can regularly be re-appropriated indicates the efficacy of generative creative processes.

Pharmaceutical companies search the rich ecosystems of uncharted rainforest for novel species that might offer medicinal utility. Rather than being a coincidence that natural evolution generates things that are useful to humans without having evolved for this purpose, this seems to be more likely to reflect a simple principle that things useful for one purpose can be useful for others. Similarly, such companies search for new synthetic drugs by brute force, testing each candidate for a number of effects (not one specific goal). At the extreme, the side effects of a drug are noted in case there are novel effects that could be of use: putting solutions before problems.

As before, those who prefer to see natural evolution as more of an adaptively creative process, may prefer to see the above as a case of the transferability of adaptive creativity from one domain (what it evolved for) to another. This is discussed in the following section.

The same reasoning can be applied to the potential for artificial generative creative systems to produce artistic material. The *Creative Ecosystems* project at the Centre for Electronic Media Art (McCormack and Bown 2009, Bown 2009) has explored the creative potential of ecosystem models, even if those models are closed and not responding to the requirements of human "users". The output of a generatively creative virtual ecosystem can be of direct aesthetic value, through the generation of inherently fascinating patterns and behaviours, in the same way that the products of natural evolution are an endless source of aesthetic fascination. This is based on the assumption that complex structure and behaviour geared to an emerging purpose, one that is generated from within the system, is meaningful and compelling. This may require the hands of a skilled artist to be fully realised. It may also be possible to develop methodologies that allow creative design to become more tightly coupled with simulated ecosystemic processes, so that someone working within a creative domain can apply ecosystemic tools in order to generate novel outputs that are appropriate to that domain.

Given the generatively creative potency of natural evolution, artificial evolutionary ecosystems, if successful, might demonstrate computational generative creativity applicable to artistic outputs. But more commonplace generative creativity can be found in existing approaches to creative computing (Whitelaw 2004), for example in which stochastic processes can be used to generate infinite variations on a theme. A common practice in electronic music production is to implement rich generative processes that exhibit constant variation within given bounds and then either search the parameter space of such processes for good settings which can be used as required, or record the output of the process for a long time and select good sections from this recording as raw material. In both cases, a generative creative process (one which is in no way coupled to the outside world of value, and also, in most cases, has no internal value system either) is itself a creative output, but also plays the role of a tool for generating useful output. Such systems can only be involved in adaptively creative processes with an adaptively creative individual masterminding this process.

Multi-agent approaches such as the ecosystemic approach discussed here, and attempts at creative social models, such as those of Miranda et al. (2003), are also different in that they do contain a notion of value internal to the system. This means that they can potentially be generators of adaptive creativity, and that potentially we may be able to find ways to couple the value system found within a model to that found in the outside world. One solution has been proposed by Romero et al. (2009) in their Hybrid Society model, in which human and artificial users interact in a shared environment.

### *14.4.2 Adaptive Creative Systems Can Be Useful to Others*

Individual adaptive creativity can be useful to others in two ways: firstly many individual innovations, such as washing food, are innovations that are both immediately useful to the individual that makes the innovation, and also to others who are able to imitate the behaviour. In this way, imitation and creativity are linked by the fact that the more adaptively creative one's conspecifics are, the more valuable it is to imitate their behaviour. They are likely to have discovered behaviours that are useful to themselves, and by virtue of your similarity, probably useful to you too (although by no means definitely). Adaptive imitation of behaviour is a particularly human capability, and a challenging cognitive task (Conte and Paolucci 2001). The imitation of successful behaviours allows human social systems to be cumulatively creative, amassing knowledge and growing in complexity (Tomasello 1999). Secondly, as discussed in Sect. 14.3.2.2, social structures bind individuals together into mutually adaptive behaviours: John Harrison did not build clocks so that he himself could better tell the time at sea.

How this common or mutually adaptive value works in the arts, however, is less clear, since the value of any individual behaviour is determined not with respect to a static physical environment but a dynamic social one (Csikszentmihalyi 1996). Whereas the value of washing food does not change the more individuals do it, the value of an artistic behaviour can change radically as it shifts from a niche behaviour to a mainstream one. In this way, copying successful behaviour does not necessarily lead to an accumulation of increasingly successful behaviour, as in the accumulation of scientific knowledge, but can also lead to turbulence: unstable social dynamics predicated on feedback. The value of artworks to individuals is highly context-specific and suggests this kind of dynamic. Thus it seems more appropriate to look to the second way in which adaptively creative systems can be of use to others, by being locked into mutually beneficial goals through social structures, but also to recognise that copying successful styles is an essential part of this process. The arts appear to involve *ad hoc* groupings of individuals who share common goals, into which adaptively creative arts-based computational systems could become integrated and be of benefit to individual humans. This points to the idea that achieving success in arts-based computational creativity is as much a matter of establishing appropriate individual and social creative contexts, practices and interfaces as it is of designing intelligent systems.

The *Drawbots project* investigated the idea of producing physically embodied autonomous robot artists which could honestly be described as the authors of their own work, rather than as proxies for a human's creativity (Bird and Stokes 2006). This would have overcome the limitations to the agency of the software in examples such as Harold Cohen's *AARON* (McCorduck 1990), where Cohen is clearly the master of the creative process, and AARON the servant. The project illustrated the fundamental conundrum of attempting to embed an artificial system into an artistic context without proper channels through which value can be managed. In fact, the drawings produced by the Drawbot were no more independent of their makers than AARON's, and arguably had less of a value connection to the outside world than AARON did, even though AARON's connection was heavily mediated by Cohen, its proverbial puppeteer. The Drawbots possessed independence in a different sense, in so far as they were embedded in their own artificial system of value. Thus each individual Drawbot was individually adapted (the product of an evolutionary process) but not adaptively creative, and the entire system was generatively creative (able to lead to new patterns and behaviours) but also not adaptively creative, and thus not creative in the sense of a human artist.

## 14.5 Conclusion

In the last example and elsewhere in this chapter I have linked a discussion of generative and adaptive creativity in social systems and individual humans to research in arts-based computational creativity and its goals. Arts-based computational creativity is well underway as a serious research field, but it faces a truly grand challenge. There is still some way to go to break down this challenge into manageable and clearly defined goals, frustrated by the ill-defined nature of artistic evaluation. But a pattern is emerging in which arts-based computationally creative systems can be categorised in terms of how they relate to the wider world of human artistic value, either as prosthetic extensions of individual creative practices, as in the case of AARON and many other uses of managed generatively creative processes, or as experiments in adaptive creativity which are generally not presently capable of producing valued artistic output, such as the DrawBots project and various models of social creative processes. In the case of artificial generatively creative systems, the analysis presented here suggests that it is important to analyse such systems both as tools in an adaptively creative process involving goal-driven individuals, and as elements in a heterogeneous social network which itself exhibits generative creativity. In both cases, it is valuable to consider what status such systems will possess in terms of primary and secondary agency.

As long as adaptive and generative creativity can be recognised as distinct processes, they can be addressed simultaneously in a single project. For example, the ecosystemic approach mentioned in Sect. 14.4.1 attempts to straddle these areas of interest by acting both as a generative tool, of direct utility to artists, and as a virtual environment in which the potential for adaptive creativity by individual agents can be explored. In this way, methods might be discovered for coupling the value system that the artist is embedded in and the emergent value system within the artificial ecosystem. The latter may be a simulation of the former, or a complementary generative system. Furthermore, since novel arts-based computational creativity technologies can be shared, modified and re-appropriated by different users, they already have a social life of their own as secondary agents, even if they are not primary social agents. As such they are adaptive in a memetic sense. Both this and the ecosystemic approach may be able to offer powerful mechanisms for bootstrapping arts-based computational creativity towards increasingly complex behaviours, greater artistic success, and an increased appearance of primary agency, without modelling human cognition.

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