Intelligent design: going back to Darwin for a better computational model of creation

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Models of creativity based on natural evolution have taken the genetic code of modern genetics, and ignored the goal-less nature of Darwin's original theory. This paper uses the comparison with evolutionary theory to suggest that exactly the opposite approach should be taken if we plan to more accurately model the processes of human design creativity.

1.0 Introduction

Evolution in nature has been held as a paradigmatic model for creativity, and is exploited in design via evolutionary computation such as genetic algorithms [1] and genetic programming [2]. While these computational processes have been shown effective for optimisation, optimisation is not the same thing as creative design.

The ultimate objectives of evolution in nature and design are similar, but the mechanism is different, and unfortunately evolutionary computation differs from natural evolution in exactly the opposite way to the way design does. This position paper suggests there are two popular errors in these evolutionary models of creative design:

- Models of creative thought that require an end goal are fundamentally mistaken. On this point they should be more like evolution.
- Models of creative thought that are based on the manipulation of a symbolic code are fundamentally mistaken. On this point they should be more like design.

Design will be compare with evolution to illustrate this position. It will be suggested that creativity has more in common with Darwin's original proposition than with the subsequent additions of modern genetics.

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2.0 Nature has no 'telos', and neither does design

Perhaps the most radical and contentious implication of Darwin's theory of evolution at the time it was proposed was that it did away with the notion of a *telos*, or end goal in nature. The mechanism of selection from random variation made this unnecessary at two scales: at the global level in the long term it required no divinely held model of perfection to which successive generations would approach, and within each generation there was no Lamarckian process of adaptation by the effort of individual organisms to their own goals. These teleological objectives were replaced by the single criterion of survival, which could be achieved by any means—strength, agility, camouflage, poison or an unusually large and adaptable brain—to suit and exploit any number of possible niches in an ecosystem.

It is exactly this ability to provide what appear to be good solutions to problems that had never been posed as such that makes evolution such a powerful model for design. Design tasks—the really creative ones—are also rarely posed explicitly. They consist of what Rittel and Webber [3] call 'wicked' problems, in that they are ill-defined and their so-called solutions have unforeseeable consequences. Rosenman [4] suggests the lack of prior knowledge about a problem is the indication of how much creativity is required. A priori goal setting is at odds with creative design.

The real power of Darwinian evolution to cope with a lack of goal is that rather than setting instructions for an outcome beforehand, it can select the results after they have been produced, and thereby make evaluations holistically. Steadman [5] notes the difference between 'instructive' and 'elective' processes in design as equivalent to the theories of Lamarck and Darwin respectively. The complexity of an organism, or of a design in its social, cultural, stylistic and functional context, means that it cannot be reduced to its parts—the way these act and interact together produce the emergent and unforeseeable consequences referred to above. The simple explanation in Darwin's theory is that such emergent complexity is possible simply because *it works*. By requiring only 'survival', evolution will both select for the whole package and allow the apparent definition of fitness to change. Most thorough accounts of the design process [6,7] emphasise the reflective processes (e.g. sketching and discussion) that redefines design objectives over time in this way. There is evidence to suggest that human designers are also able to evaluate a great deal more in a design than they are able to instruct [8].

Our assumption of teleology in design may come from a common sense perception of the creative act as a personal, individual phenomenon, and from a design profession that does apparently have goals. Social models of creativity [9] suggest that this may not actually be so. Even professional designers draw the bulk of their output by working within existing types so ubiquitous as to be unquestioned and unnoticed, and the small remaining portion that is actually novel may still be inspired by what already exists. The position of this paper is that all novelty is actually derived from what already exists; the mechanism for this is described in the following section.

3.0 Nature has genotypes, but design does not

The major non-Darwinian contributions to our modern understanding of evolution, from Mendel's [10] description of the laws of inheritance to Watson and Crick's [11] discovery of the molecular structure of DNA, pertain to the *mechanism* by which nature's designs are produced. The notion of an underlying code has such an affinity to computation that it is no surprise that they have often been adapted as a mechanism for supposedly creative systems. This relationship may be partly historical, as the years immediately following the discovery of the biological code also focused on formal symbol systems [12] as the basis for intelligence and language [13]. Much of this work paralleled the 'central dogma' of molecular biology, in which information can only be passed in one direction—from genotype (the code, or DNA) to phenotype (the organism's traits), and never the reverse [14].

But this has little to do with how design really works, for the simple reason that nothing like this dogma holds for human creativity. Instead of the genotype, it is precisely the phenotype, or traits of designed artefacts, that as designers we are able to copy or modify in creating a new work. In some cases where a genotype is proposed as an analogy to our understanding of human artefacts, it is specifically 'inverted' [15] such that information can flow back. To propose a plausible model of creative thought with some that resemblance to evolution, it is the notion of a genotype, or any fixed symbolic representation, that must be rejected.

The importance of operating at the level of the phenotype is that while a genotype is a fixed, symbolic representation that can only be translated in one way, it is at the level of final traits that *multiple interpretations* may be made. The act of reinterpretation has often been identified as important to creative thought: Schön [16] calls this 'seeing-as'; Koestler [17] discusses the 'bissociation of matrices'. I would go further to suggest that this act is not only the very root of creative insight and the generation of novelty, but it is only through the ability to make multiple interpretations of a single phenotype (violating the dogma of molecular biology) that we have the ability to be creative in design.

The argument is not based on new empirical evidence, but because existing alternative assumptions have less explanatory power. There is a general consensus that creativity requires the apparently paradoxical combination of novelty and utility [18], and this novelty is built in to computational models. Evolutionary computation such as genetic algorithms and genetic programming rely on a simple random number generator to produce mutations and control gene crossover. Some models are more refined with goal directed behaviour, such as Saunders and Gero's [19] creative agents, who are given a pre-programmed optimal balance between too much and too little novelty as suggested by Berlyne [20], but still the generation of that novelty is given by random generation. Although a random number generator can be said to fill in for real variation in the world, and agents might be modelled on a belief that we are imbued with an innate élan vital [21], these models still beg the question of the explanation of that novelty.

The ability to make multiple interpretations of a single phenotype explains how novelty can occur. It can happen in at least two different ways roughly analogous to those known to occur in the genotype. Genetic *mutation* is essentially a copying error in DNA. When an attempt is made to faithfully copy phenotype traits of a designed artefact, there is inevitably some capacity for unintentional change, becoming more likely the less is known about the process by which the original was made (its genotype). Genetic *crossover* is the combination of two dissimilar sets of DNA via sex. This is the really big creative bang—Koestler's bissocation of dissimilar matrices, or the "eureka moment". Had Archimedes been constrained to think in terms of the *genotypic* properties of baths and votive crowns (e.g. the ideal water temperature; how to shape a gold-silver alloy) he would not have made a creative leap that depended on *phenotypic* traits, or resultant effects, such as water displacement and density.

This ability of 'seeing-as', explains this emergence of novelty without the need for goal-seeking behaviour or resort to imposed randomness. We get something from nothing in that innovation emerges naturally as a consequence simply of observing.

Many of the apparent contradictions or paradoxes of creativity concerning the trade-off between novelty and utility can be explained. Berlyne [20] suggests a curve based on Wundt [22] gives an optimal level of novelty, but there is little to suggest any intrinsic benefit of novelty. Udo Lindemann recently questioned such motives at a recent SIG Design Creativity workshop (DESIGN 2010, notes: Tom Howard), in that it is generally more important just to do things in the best way, rather than a new way. For Cropley [18] it is paradoxical that creativity "requires deviating from social norms, but doing this in a way that the society can tolerate". These points are only contradictory if novelty is measured by a standard metric, as would be the case with genotypes. Multiple interpretations of a phenotype imply that there is no single standard, so something may be highly unusual in one axis of measurement while at the same time instantly recognisable in another. My novel is not your novel.

Although little has been done in terms of reinterpreting the phenotype, evolution improves simply by changing features of genetic representation such as the numerical base [23]. Phenotype operations should be even faster at producing innovation, a point on speed that is often made in comparing cultural with biological evolution. If this is so, then it would form the latest of a set of radical changes in how evolution functions: the beginning of mutation in the genome 3.8 billion years ago; sexual crossover 1.2 billion years ago; and the cultural copying at the level of the phenotype within the last several hundred thousand years. Each of these steps has been accompanied by a dramatically increased rate of change.

4.0 Where research should focus

The relationship between design and evolution has more to do with the capacity to naturally select good solutions holistically to emergent criteria than with the underlying genetic code that is so often assumed. Design thus has more in common with Darwin's model, prior to the discovery of a coded genotype. In the sense that creativity is often thought to be a somewhat vague and slippery concept, the rejection proposed here both of set goals and clear codes is perhaps not surprising, but does raise questions of how research might continue. While optimisation can focus on better means of search, what can be done without the telos or the code?

We are not left without a mechanism. For novelty, we need to know how interpretation of artefacts occurs. AI is now beginning to explore this, through e.g. machine learning and vision, embodied robotics and the commonplace manipulation of unprecedented amounts of data by Google. For utility, without a telos this seems more difficult, but in design we also rely on existing artifacts to guide our choices, basing our assumptions on things tested in the real world, where unspecifiable goals constantly arise by emergent process. Both elective, goalless processes and novelty generation are based on observing or interpretation, and these mechanisms provide much to investigate.

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