The Beer Can Theory of Creativity

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4.1 INTRODUCTION

I had to laugh this morning while reading the Ottawa Citizen when I saw a crafty yet bafflingly incompetent vandal described as "He's got a full six pack, but the plastic thingy that holds them together is missing." It's a spin-off of the saying "He's one can short of a full six pack," which itself is a Canadianized version of "He's lost a few marbles" or "He's not playing with a full deck."

The newspaper description beautifully exemplifies one of the main issues of this chapter—that the interplay of variation and continuity as a creative insight is adapted from one context or circumstance to another. But also, content-wise, it's a pithy summary of another, related issue dealt with here. In order to adapt the idea to a new context, in order to evolve it in new directions, it must originally have been stored in memory in a way that implicitly identifies its relationships to other ideas. In other words, when it comes to creativity, how your "beer cans" are connected together is as important as how many of them there are.

This chapter explores the cognitive mechanisms underlying the emergence and evolution of cultural novelty. Section 4.2 summarizes the rationale for viewing the process by which the fruits of the mind take shape as they spread from one individual to another as a form of evolution and briefly discusses a computer model of this process. Section 4.3 presents theoretical and empirical evidence that the sudden proliferation of human culture approximately two million years ago began with the capacity for creativity—that is, the ability to generate novelty strategically and contextually. Finally, Section 4.4 wraps things up with a few speculative thoughts about the overall unfolding of this evolutionary process.
4.2  CULTURE AS AN EVOLUTIONARY PROCESS

When asked in an interview “What is creativity?” Russian dancer Rudolf Nureyev gave the following answer:

It is something born from within you. It’s as though you felt a need to do something, to say something, to utter, and you cannot live without uttering this sentence or writing this piece of music. It just begs to manifest itself. It is a need to express yourself first, and then to rationalize this expression. It is irrational first, rational after. I am sure Einstein had an inkling about something unknown and then came to his theory of light. And I am sure everybody has had this impulse, very much akin to sex, sexual drive, or sexual appetite, if you wish (LeMay 1990).

It is fascinating that people frequently describe their creative process through metaphorical allusion to how novelty arises in the biological world. Is this merely tactical? For example, since everyone has experienced sexual drive, does comparing the creative impulse to it hull us into a romanticized view of the extent to which the creative impulse possesses one who gives their life over to it, not voluntarily but because that is their nature? And when artists use the word “birth” to describe the process by which something vaguely intuited, and perhaps seemingly irrational, is nurtured into the rational realm of human events and understandings, are they manipulating us into viewing their works with the reverence with which we view a newborn child? Or is there really a deep isomorphism between these two processes?

4.2.1  Variation and Convergence in Biology and Culture

Increasingly, culture is being viewed as a form of evolution (for example, Campbell 1974, 1987; Cavalli-Sforza and Feldman 1981; Csikszentmihalyi 1993, 1999; Gabora 1996, 1997; Popper 1963). To see why, we need to take a closer look at what evolution is: a process wherein a stream of information incrementally adapts to environmental constraints. It requires

+ a pattern of information (an entity that occupies a state within a space of possible states)
+ a means of varying the pattern (exploring or transforming the space)
4.2 Culture As an Evolutionary Process

+ a rationale for selecting or converging on variations that are adapted, that is, that tend to give better performance than their predecessors in the context of some problem or set of constraints (a fitness landscape applied to the space)

With each iteration of variation and selection, the evolving entity is often better able to meet the challenges and capitalize on the opportunities presented by its circumstances; in a sense it becomes a sharper “mirror image” of its environment. The situation is complicated by the fact that the entity’s environment often consists largely of other entities that are themselves evolving, so predator-prey relationships, symbiotic alliances, and coevolutionary arms races become established.

In biological evolution, the evolving patterns of information are genes encoded as sequences of nucleotides. Variation arises through mutation and recombination, and natural selection weeds out those that are maladapted. In cultural evolution, the evolving patterns of information are concepts, ideas, attitudes, values, and so on. Variation is generated by “creatively” combining, transforming, and restructuring them. Factors promoting convergence include biological drives, goals, desires, values, aesthetic preferences, and the associative organization of memory, which constrain how one concept evokes (in a sense, selects) another. Actually, in the cultural domain, variation and convergence tend to go hand in hand; this process will be explored in detail shortly.

The cultural analog of the genotype is the network of concepts and ideas that together constitute a model of reality, or worldview. The analog of phenotype is the way they get implemented or communicated, through facial expressions, gestures, actions, or vocalizations. Implementation incorporates syntactic features characteristic of the channel through which it is conveyed (Brooks 1986). Thus, for example, a dance step looks different with each individual who performs it. Whereas biological information gets passed on to offspring as a complete set of genes, cultural information spreads one idea at a time.

The assimilation of new ideas into a society alters the selective pressures and constraints it exerts on the individuals embedded in it, which in turn alters the generation and proliferation of future ideas. Thus culture, like nature, comprises a self-sustained system for the exploration and transformation of a space of possible patterns.

1. Sometimes units of cultural information are referred to as “memes,” a term I now tend to avoid because of its reductionist overtones.
4.2.2 Is More Than One Mind Necessary for Ideas to Evolve?

Sometimes a fourth item is included in the list of requirements for evolution: a way of replicating (or amplifying, as molecular biologists refer to it) the selected variations. Ideas are said to replicate through social processes such as teaching and imitation. Clearly replication is an integral component of biological evolution, and the transmission of ideas through social processes such as imitation and teaching is likewise important. But is it indispensable? If, for example, you were the only human left on the planet, but you could live forever, would cultural evolution grind to a halt? If you found an ingenious way to scale a mountain, you would still have come up with something new, something more adapted to the environment, something that you might go on to modify and perfect—to evolve. Your novel mountain-scaling approach might even lead you, through metaphorical analogy, to new ideas about how to elevate your mood, or expose you to mountain plants and thereby lead to novel ways of cooking them, weaving them, and so on. Thus, strictly speaking, there need not necessarily be more than one individual for culture to evolve. Evolution can occur through variation and convergence acting on a single stream of information (such as a train of thought) without anything being explicitly replicated. There is no more reason to refer to this as “replication” than to refer to your cat now as a “replicant” of the cat that jumped on the windowsill a few minutes ago. The conscious experience of an individual can be viewed as an evolutionary process in which variation and convergence are not separated spatio-temporally but intimately intertwined, one pattern of qualia fluidly transmuting into the next.

Nevertheless, the “culture” of a single individual would be impoverished, to say the least. Cultural variety increases exponentially as a function of the number of creative, interacting individuals. As a simple example, a single individual who invents 10 new words is stuck with just those 10. A society of 10 interacting individuals, only one of whom is creative, is no better off; there are still just 10 words. In a society of 10 non-social individuals, each of whom invents 10 words but does not share them, each individual still has only 10 words. But in a society where the 10 individuals invent 10 words and share them all, everyone ends up with 100 words.

The bottom line is, culture as we know it, with its explosive array of meaningful gestures, languages, and artifacts, requires the kind of parallel processing that social interaction provides. But—if you accept the views described here—it is possible for a single individual to evolve cultural novelty.
4.2.3 Meme and Variations: A Computer Model of Cultural Evolution

This can be seen clearly in Meme and Variations (MAV), a computer model of cultural evolution (Gabora 1995). The program consists of an artificial society of interacting neural-network-based agents that do not have genomes, and neither die nor have offspring, but that invent, implement, and imitate ideas, or memes. Every iteration, each agent has the opportunity to acquire a new meme, either through (1) innovation, by mutating a previously learned meme, or (2) imitation, by copying a meme implemented by a neighbor. Whereas memes do not evolve at all in the absence of innovation, meme evolution does take place in the absence of imitation (albeit more slowly). In other words, when agents can generate novelty, but completely ignore one another, memes still evolve.

MAV displays many phenomena found in biological evolution, such as drift, and slower increase in fitness at epistatic loci. It also displays phenomena unique to culture. For example, mental simulation (ability to assess the relative fitness of a meme before actually implementing it) and strategic innovation (using past experience to bias how memes mutate, as opposed to mutating at random) both increase the rate at which fitter memes evolve.

The higher the ratio of innovation to imitation, the greater the meme diversity, and the higher the fitness of the fittest meme. However, meme fitness increases most rapidly for the society as a whole with an innovation to imitation ratio of 2:1 (but diversity is then compromised). Interestingly, for the agent with the fittest memes, the less it imitates (i.e., the more computational effort reserved for its own creative efforts), the better it performs.

The approach taken in MAV can be compared with Sims’s (1991) and Todd and Latham’s (1992) computer models of the evolution of creativity, which, though they explore a cultural process, use a genetic algorithm—a model of biological evolution. However, although MAV is modeled after cultural evolution, it is too simple to explore many cultural phenomena. The space of possible memes is fixed and small, and (unlike real life) the fitness function that determines what constitutes a good meme is predetermined and never changes. Also, imitation and innovation are probably not as discrete as the model suggests. Nevertheless,
it demonstrates the feasibility of computationally modeling the processes by which creative ideas spread through a society, giving rise to observable patterns of cultural diversity.

4.2.4 Breadth-First versus Depth-First Exploration

The following distinction can be useful for gaining insight into why, as we saw in Sections 4.2.2 and 4.2.3, it isn't essential that individuals imitate (or that there even be more than one of them!) for culture to evolve. Biological creativity is largely random. Billions of mutant gametes are ejected into the world, and most are unsuccessful, but the occasional one is better than the average, and over generations it tends to increase in the population. This kind of approach—search the entire space of possibilities without devoting much effort to any one possibility, and probably at least one of them will be better than what exists now—is referred to in computer science as breadth-first.

Human creativity, on the other hand, is highly nonrandom. Say, for example, you are faced with the problem of how to stop a leaky faucet from dripping. If you were to try to reach a solution by mutating each feature of the dripping faucet one by one, or by recombining it with every concept from hot dogs to postmodern deconstruction, you wouldn't get very far. We generate novelty strategically, using an internal model of the relationships among the various elements of the problem domain, and contextually, responding to the specifics of how the present situation differs from previously encountered ones. This kind of approach—explore few possibilities, but choose them wisely and explore them well—is referred to as depth-first.

In a sense, culture embodies the best of both worlds; that is, each individual's depth-first stream of thought is embedded in a highly parallel, relatively breadth-first social matrix that provides a second, outer tier of convergent pressure. For depth-first search to be successful, of course, requires some knowledge of the topology of the fitness landscape; in other words, some "smarts" about what sort of variation and convergence would probably be beneficial. Of course, even a relatively breadth-first algorithm like biological evolution operates with a certain degree of smarts. In fact it is sometimes argued that it too is highly nonrandom, though clearly it is not strategic and contextual in the way a stream of thought is. So the distinction is just a matter of degree.
4.2.5 Dampening Arbitrary Associations and Forging Meaningful Ones

Whether or not an algorithm is breadth-first or depth-first, the notions of linkage equilibrium and disequilibrium are useful conceptual devices for gaining an overview of what is taking place during an evolutionary process. The closer together two genes are on a chromosome, the greater the degree to which they are linked. Linkage equilibrium is defined as random association among alleles of linked genes. Consider the following simple example:

- A and a are equally common alleles of Gene 1.
- B and b are equally common alleles of Gene 2.
- Genes 1 and 2 are linked (nearby on the same chromosome).

There are four possible combinations of genes 1 and 2: AB, Ab, aB, and ab. If these occur with equal frequency, the system is in a state of linkage equilibrium. If not, it is in a state of linkage disequilibrium. Disequilibrium starts out high, but tends to decrease over time because mutation and recombination break down arbitrary associations between pairs of linked alleles. However, at loci where this does not happen, one can infer that some combinations are fitter, or more adapted to the constraints of the environment, than others. Thus when disequilibrium does not go away, it reflects some structure, regularity, or pattern in the world.

What does this have to do with creativity? Like genes, features of memories and concepts are connected through arbitrary associations as well as meaningful ones. We often have difficulty applying an idea or problem-solving technique to situations other than the one in which it was originally encountered, and conversely, exposure to one problem-solving technique interferes with the ability to solve a problem using another technique (Luchins 1942). This phenomenon, referred to as mental set, plays a role in cultural evolution analogous to that of linkage in biological evolution. To incorporate more subtlety into the way we carve up reality, we must first melt away arbitrary linkages among the discernable features of memories and concepts, thereby increasing the degree of equilibrium. This needn't be a particularly intellectual process; for example, the feeling of a particularly painful or joyous experience could be extricated from the specifics of that experience, and remanifest itself as, say, a piece of music. As we destroy patterns of association that exist because of the historical contingencies of a particular domain, we pave the way for the forging of associations that reflect
genuine structure in the world of human experience that may manifest in several or perhaps all domains.

Nureyev revealed an at least intuitive grasp of this when, further on in the interview, he was asked, "Has going from [dance to acting] given you any insight into the previous kind of performance styles, and into the different shades of creativity?" He responded: "If you know one subject very well, then you have the key to every other subject." If this is true, it doesn't seem particularly fair. Why should some people hold, not just the key to the discipline they have specialized in, but all the keys? However, looking around, there appears to be increasing evidence in support of Nureyev's claim. Complexity theory is being applied to everything from earthquake prediction, to neuroscience, to the design of an algorithm for animating the behavior of a flock of bats in *Batman*. Genetic algorithms are being used to compose music, and mathematicians are turning into fractal artists. It isn't obvious what doors will be opened by any particular key!

To briefly sum up thus far, we have examined the rationale behind viewing culture as a form of evolution—a process by which information incrementally adapts to environmental constraint through variation and convergence. In some ways these two forms of evolution operate quite differently; for example, cultural novelty is generated in a more depth-first manner. In other respects they are similar, and features of biological evolution—such as drift and linkage equilibrium—transfer readily to culture. We now turn from the general principles underlying these evolutionary systems to the question of how they began in the first place.

### 4.3 Creativity as the Origin of Culture

The origin of culture is sometimes unquestioningly equated with the onset of the capacity for social learning, and particularly imitation (for example, Blackmore 1999). But the idea that imitation is what makes us human seems counterintuitive. When we feel proud to belong to the human race, we think of the Great Pyramids, beautiful music, the airplane... in short, the fruits of *creativity*. The word "imitation" is, in fact, often used to denote inferiority. Are our intuitions about what makes us special actually misguided? I think not. There are several sources of evidence that creativity, not imitation, is what makes us human.
4.3.1 Theoretical Evidence

We saw in the MAV computer model that when the agents' ability to imitate is set to maximum, and their ability to invent is turned off, nothing happens. This makes sense. There has to be something worth imitating before the ability to imitate comes in handy, or even manifests itself. A society of individuals who can imitate, but not invent, is stagnant. Therefore, the suggestion that it was the appearance of imitation that brought about the onset of culture is not theoretically sound.

On the other hand, recall how when the MAV agents' ability to invent is set to maximum, and their ability to imitate is turned off, evolution does take place, albeit more slowly than with imitation. Since, as we have seen, cultural evolution is more depth-first than biological evolution, once the capacity for creativity presents itself, culture can evolve, whether or not there is imitation. Novelty can then breed more novelty. Or as one choreographer put it: "If we don't do what our predecessors did, we're doing what our predecessors did." Thus the proposal that culture originated with the onset of creativity is at least theoretically possible.

4.3.2 Archeological Evidence

Human culture is generally thought to have originated somewhere around 1.7 million years ago, during the time of *Homo erectus*. This period marks the appearance of sophisticated stone tools and habitats, use of fire, long-distance hunting strategies, and migration out of Africa, as well as a rapid increase in brain size (Bickerton 1990; Corballis 1991). This increase in variety of artifacts and habitats is exactly what one would expect to see if humans suddenly acquired the capacity to be creative. It is the *opposite* of what one would expect if they suddenly acquired the ability to imitate. If it were imitative capacity that had suddenly arisen, then just prior to this time there would have been a great variety of tools, habitats, and so on, and the onset of imitation would have funneled this variation in just a few of the most useful directions. Thus the archeological evidence is consistent with the thesis that creativity, not imitation, was the funnel for culture.
4.3.3 Evidence from Animal Behavior

Experimental research indicates that imitation (and related phenomena such as emulation, response facilitation, etc.) is widespread in the animal kingdom. It has been documented in budgerigars (Galef et al. 1986), quail (Akins and Zentall 1998), cowbirds (King and West 1989), rats (Heyes and Dawson 1990; Heyes, Dawson, and Nokes 1992), monkeys (Beck 1976; Hauser 1988; Nishida 1986; Westergaard 1988), orangutans (Russon and Galdikas 1993) and chimpanzees (Goodall 1986; Mignault 1965; Sumita, Kitaham-Frisch, and Norikoshi 1985; Terrace et al. 1979; Whiten 1998). Nevertheless, as many authors have pointed out, although imitation is commonplace, no other species has anything remotely approaching the complexity of human culture (for example, Darwin 1871; Plotkin 1988).

As we have seen, imitative capacity remains latent, hidden from view, until there is variation for it to work on. Thus the lack of cultural complexity in animals despite evidence that, when put to the test, they can imitate, is consistent with the "creativity as funnel for culture" proposal.

4.4 WHAT CAUSED THE ONSET OF CREATIVITY?

What then could have caused humans to suddenly be capable of generating strategic, contextual novelty? For a stream of creative thought to unfold, related memories and sensorimotor behaviors (some hard-wired, some learned) must become woven into an interconnected conceptual web, or worldview. However, this presents the following paradox. Until a mind incorporates relationships between memories, how can one thought evoke another? And until one thought can evoke another, how are relationships established among memories so that they become an interconnected worldview?

The origin of life presents an analogous paradox: If living organisms come into existence when other living things give birth to them, how did the first organism arise? That is, how did something able to reproduce itself come to be? By combining an insight from random graph theory with the concept of hypercycles Kauffman (1993) arrived at the hypothesis that life may have begun with, not a single molecule capable of replicating itself, but an autocatalytically closed set of collectively self-replicating molecules. (Note that it is not closed in the sense that new molecules cannot be incorporated into the set. It is closed in a mathematical sense, but not a physical sense.)
4.4 What Caused the Onset of Creativity?

An analogous line of reasoning can be applied to explain how discrete memories become woven into a worldview. Although this account focuses on integration of the worldview through the emergence of deeper, more general concepts, the principles apply equally to integration of the psyche through the purification of intentions and emotions. A detailed account of the proposal can be found in Gabora (1998), and elaborations in Gabora (1999, 2000), but the basic line of reasoning goes as follows. Much as catalysis increases the number of different polymers, which in turn increases the frequency of catalysis, reminding events increase concept density by triggering abstraction—the formation of abstract concepts or categories such as “tree” or “big”—which in turn increases the frequency of reminding. And just as catalytic polymers reach a critical density where some subset of them undergoes a phase transition to a state where there is a catalytic pathway to each polymer present, concepts reach a critical density where some subset of them undergoes a phase transition to a state where each one is retrievable through a pathway of reminding events or associations. Finally, much as autocatalytic closure transforms a set of molecules into an interconnected and unified living system, conceptual closure transforms a set of memories into an interconnected and unified worldview. Memories are now related to one another through a network of abstract concepts; the more abstract the concept, the greater the number of other concepts that fall within a given distance of it in conceptual space and therefore are potentially evoked by it. For instance, your concept of “depth” is deeply woven throughout the matrix of concepts that constitute your worldview; it is latent in experiences as dissimilar as “deep swimming pool,” “deep-fried zucchini,” and “deeply moving book.”

It seems likely that to produce a stream of meaningfully related yet potentially creative reminding, memories need to be distributed (though their distribution must be constrained). The process described here would most likely have been kickstarted by a genetic mutation leading to decreased neuron activation threshold, causing the storage and retrieval of memories to become more widely distributed.

So, to return to the Bob and Doug MacKenzie parlance with which this chapter began, culture may have begun with the emergence of a “plastic thingy”—a hierarchical network of abstract concepts that connects associated memories into a worldview. Some experiences are either so consistent, or so inconsistent, with this worldview that they have little impact on it. Others percolate deep, renewing our understanding of myriad other concepts or events. The worldview is stable if it fosters thought trajectories that enhance individual well-being. Much as biological organisms assimilate the food necessary for maintenance and growth but shield off toxins, an individual assimilates stimuli that
expand its worldview, but censors or represses stimuli or memories that could bring harm.

A relationally and hierarchically structured worldview would be invaluable in biasing the generation of novelty in directions that are likely to be fruitful. (How this could work is discussed in depth in the extended version of this chapter on the CD-ROM.) Actually, a relationally and hierarchically structured worldview probably aids imitation too, especially the imitation of actions, vocalizations, or artifacts that are particularly complex (Byrne and Russon 1998). For example, a novel mannerism or expression could be generated by putting your own slant on it on the fly, as you imitate. So the dichotomy between creativity and imitation may be less polarized than the preceding discussion implies. Nevertheless, imitation without creativity is not sufficient to bring about cultural evolution.

4.5 CONCLUSIONS

It may be that this chapter has barely touched on what lies at the crux of creativity. It may turn out that religious and spiritual traditions have more to offer here of explanatory value than does science. Nevertheless, the notion that cultural, as well as biological, information evolves through variation and convergence surely gives new vitality to our understanding of the creative process, both at the individual level and the cultural.

Of course, there are significant differences between biological and cultural novelty. In the biological realm, novelty is generated by combining and mutating information units. But in the cultural realm, all sensory information gets more or less thrown into one big melting pot (or keg, you might say), that is, the conceptual network, or worldview, and novelty is generated strategically and contextually, by highlighting those aspects of the worldview most relevant to the current situation. It may be that the origin of the capacity to weave memories into a worldview through the formation of abstractions gave rise to the origin of culture. And you could say that creativity is the crystallized precipitate of these worldview weavings.

Everyone is creative. Every inkling in every mind alters, however minutely, the structure of a worldview that, through the spoken word, the holding of hands, and so on, interacts with other worldviews and is part of a vast chain of worldviews evolving through space and time. Nevertheless it is interesting to ask: Was Einstein a seven-pack? Or was he a regular six pack like most of us, but one in which the plastic thingy melted and resolidified in a truly exceptional way? Probably both. But the second is more likely what led him to be "person of the
century" (according to *Time* magazine). The greater the number of concepts, the more levels of hierarchically structured abstraction are possible, but only some of these capture regularity of the world and therefore have meaning. So once there's a certain number of concepts in there, what matters most is how the individual weaves them together. In fact, up to an IQ of 120, intelligence and creativity are correlated, but past 120 they are not (Barron 1963). My guess is that Einstein had a tendency toward defocused attention and conceptual fluidity, and as a result, his worldview was less a product of what he was taught, and more a self-made construction from the bottom up. And the worldview weavings of the human race will, of course, never be the same.

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