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COMMENTARIES

Creative Expertise as Superior Reproducible Performance: Innovative and Flexible Aspects of Expert Performance

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In his interesting and provocative target article Simonton (this issue) argues that a remarkably broad range of creative human achievements can be accounted for by a very general process of blind variation and selective retention, which he traces back to Darwin's theory of biological evolution. According to Simonton, genuine creativity involves blind variation, which is antithetical to the control exhibited in expert performance and thus raises issues regarding the nature of creative expertise and the possibility of intentional creative achievements. In this commentary I take issue with Simonton's argument that it is impossible to produce creative achievements with some reasonable degree of consistency and, in addition, that creative expertise differs fundamentally from other types of expert performance in domains, such as chess, music, sports, and medicine. In some recent articles (Ericsson, 1996, 1998; Ericsson & Charness, 1994; Ericsson, Krampe, & Tesch-Römer, 1993; Ericsson & Lehmann, 1996), my colleagues and I have proposed how the expert-performance framework can offer a promising account of the necessary conditions for creative achievements and their rare occurrence in domains of expertise. These proposals also identify acquired mechanisms that can explain the "huge … individual differences in creative behavior"—an unresolved paradox within Simonton's proposal for creativity as blind variations.

Identifying the Core Issues

The central issue addressed by Simonton concerns the evolution of new ideas and creative products: "How does the individual arrive at new ideas in the first place? How do human beings create variations?" He argues for a Darwinian account where "the variations themselves arise from a cognitive variation-selection process that occurs within the individual brain." Although I support efforts to understand the processes occurring within the brains of individuals who generate particular creative products, I am more skeptical toward Simonton's argument for parallels between human creativity and the blind mechanisms mediating biological evolution.

The primary mechanism of biological evolution is mutation, where blind influences, such as radiation, may suddenly and "unintentionally" change the chemical information encoded in genes where the corresponding new genes might lead to more fit organisms. I can see, at least, three very significant differences for human creativity. First, in contrast to instantaneous generation of a genetic mutation, the completion of specific creative achievements, such as books, paintings, and music compositions, takes considerable time on the order of days, weeks, and months or even years of sustained intentional effort. These generated products are not unintended (blind) side products of other activities: The creating individuals actively select ideas and products and refine and improve them until the individuals present the developed products to other interested members of the same culture. Second, unlike the unexpectedness of the occurrence of a mutation, individuals often spend years and decades studying and preparing for being able to complete creative products. Consequently, any generated variation by particular individuals would have to be understood within the context of their earlier learning and education and, perhaps even more important, within the context of their prior unique experiences of successes and failures involved in the generation of related products. Whether this domain-related experience influences the processes of generation by intentional factors (reportable to others) or by implicit factors in activities, "such as playful exploration, haphazard tinkering, and free association," would seem to be less important than that the generation in both cases was influenced by prior experience. Finally, in contrast to the specificity and permanence of an instantly completed mutation, it is not clear how to identify the original ideas responsible for a finished creative product. Even in those rare cases when individuals claim to have initially generated a new specific idea for a product, how can we know for certain that this idea remains the same throughout the extended period of development into a finished artistic product or a scientific argument? If the meaning of the original idea can be shown to change gradually during the extended process of development into the finished product, how could anyone (including the creators themselves) distinguish the influences of knowledge, techniques, skills, and the originally generated idea on the final creative product? Consequently, I worry about the validity of Simonton's proposal to generalize the simple blind mechanisms of biological evolution to the complexity of human creative achievement and agree with the problems and challenges originally raised by Campbell (1960) for a "theory of creative thought" (p. 397). Fortunately, the community of researchers (Csikszentmihalyi, 1994) have avoided the problem of idiosyncratic transient ideas and define creativity as an attribute of the finished public products. According to the dominant view, the final evaluation of a finished product's value is not made by the creator but by observers and distinguished members of the corresponding community and culture. This definition separates the creator's process of generation and development of the new products from the subsequent evaluation of the finished product and its creativity.

The standard definition of creativity requires that "Creativity is an attribute of ideas or products that (1) are original or statistically infrequent, and therefore *unpredictable* [italics added], in a given culture" (Csikszentmihalyi, 1994, p. 299). Furthermore, the creative ideas and products are "held valuable by the culture as whole, or by a field of experts whose opinions is held to be legitimate by the culture" (p. 299) and the creative ideas and products "are carried on to a final, or at least to a useful, completion" (p. 299). According to this definition, the judgment of creativity is made on the basis of the unpredictability and originality of products with reference to ideas and other products in a given culture. This definition would even allow the possibility that some individuals might use consistent and unique methods to generate a series of products that would generally be judged as creative. Furthermore, it is also possible that creators may sometimes generate new products that they believe to be unique and original. However, if the community recognizes that similar products have been presented previously, they will not judge those products to be innovative and creative, whether or not the creator had been exposed to the earlier creations. The judgment of creativity of a particular product by the judges may thus be disassociated from the creator's assessment of the degree of innovation involved in the generation of that product.

The consensus definition shows very clearly that the characteristics of creative products, although judged unpredictable by representatives of a culture, are by no means random in that the products must satisfy several explicit constraints to qualify as creative contributions. It is therefore possible that the variation in the skills and abilities to satisfy these constraints efficiently could explain the observed individual differences in creative achievement. First, the ideas and products have to be original and go beyond the accumulated knowledge of the field of experts. Consequently, the most effective way for an individual to be able to determine rapidly whether a generated idea would already be known to experts in the domain is to master the relevant knowledge about prior achievements in the domain. Second, anyone interested in being able to anticipate better what is valued by experts in a domain should study the teachings and the recognized masterpieces of master teachers in that domain. Finally, to present complete creative ideas or products it is necessary for individuals to master techniques and knowledge of the corresponding domain. Unless the individual has the technical mastery to develop his or her ideas or products fully, it is unlikely that judges will be able to recognize their value and potential. It is therefore not surprising that the vast majority of individuals who make major creative innovations have spent many years absorbing the knowledge, methods, and skills relevant to the domain prior to making their first creative contribution.

One of the most important advantages of the socially based definition of creativity is that judgments of creativity for the same idea and product will depend on the judges and their knowledge and experience. For example, a particular audience may perceive musicians' and dancers' performances as strikingly creative, whereas experts would judge the same performances as technically skilled but not necessarily sufficiently original to qualify as creative. Consequently, a more knowledgeable and skilled performer may well be able to produce a series of different performances that would appear quite original and thus creative to less skilled and knowledgeable members of an audience. The consensus definition of creativity can thus easily accommodate acquired skills and superior knowledge as potential explanations of large reliable individual differences in creative achievement as those observed in our culture.

Creativity and the Expert-Performance Framework

The prototypical creator is one who makes creative contributions to many different domains, such as Leonardo da Vinci. However, as knowledge and required skills have increased over historical time, creative individuals in most domains of expertise have become more specialized in the type of materials and methods that they use to create their products. The degree of specialization of creative individuals is so advanced that recent examples of famous creative ideas and products almost invariably refer to achievements by individuals who are closely associated with a single specific domain of expertise, such as Pablo Picasso, Albert Einstein, or Martha Graham (Gardner, 1993).

In all contemporary domains of expertise, procedures have evolved for identifying contributions and achievements that are not previously known to experts in the domain. These procedures serve several functions, namely to recognize outstanding individuals in the domain, as well as providing methods for organizing existing knowledge and accumulating new knowledge, new products, and new training methods, with the goal of more effectively training and educating beginners and students in the domain. Consequently, the highest level of creative achievement today is, virtually without exception, associated with a particular domain of organized activity and expertise.

Recent reviews show that individuals who have made outstanding contributions to a particular domain of expertise differ from not just random individuals in the culture but also from other typical members of their domain. As Simonton has already pointed out, there is extensive evidence that around 10 years of active involvement appear to be necessary before anyone, even the most talented, are able to reach an international level of achievement (Ericsson et al., 1993; Gardner, 1993; Simon & Chase, 1973). However, extensive experience and participation in the domain-related activities do not guarantee superior performance on representative tasks from the domain nor do they assure creative contributions to the domain. More recent reviews show that improvement from mere experience is quite limited and that increased performance is attributable to deliberate practice (Ericsson et al., 1993; Ericsson & Lehmann, 1996), which involves the engagement in special practice activities especially designed to improve particular aspects of performance, typically through successive refinements with feedback. Several recent reviews have found a consistent relation between attained level of performance and the amount and quality of deliberate practice in a large number of domains, such as chess, sports, and music (Ericsson, 1996, 1998; Ericsson & Lehmann, 1996).

According to Simonton, our recent insights into "the acquisition of expertise in particular performance domains … such as those found in sports, games, and music" does not generalize to domains focused on creative achievements. To rebut his argument, I try to show that he underestimates the role of knowledge and skills in domains that he refers to as creative. Even more important, he underestimates the flexibility and creativity of the elite levels of performance in traditional domains of expertise, as I show in the next section.

Traditional Domains of Expertise

Simonton suggests that "the criteria of success and failure are so well defined … that it is relatively easy for an aspiring expert in these domains to learn precisely what is necessary to attain world-class mastery of the skill." This view may be valid for the initial phases of expertise, because beginners in those well-defined domains are typically given a sequence of appropriate training exercises that teachers have found to guide the development of basic skills. As the students' mastery increases, the teachers and coaches design practice activities to fit the students' strengths and weaknesses (Bloom, 1985). As the students' performance level increases, the role of the teacher diminishes. Students become independent of the teacher by acquiring mental representations that allow them to anticipate feedback from teachers and other experts in the domain (Ericsson, 1996, 1998; Glaser, 1996). In some domains, such as chess, high-level performance does not even appear to depend on access to teachers. It is best predicted by the accumulated amount of solitary study of published chess games (Charness, Krampe, & Mayr, 1996). Regardless of the path to expert performance, when the performers have mastered all the essential knowledge and skills, elite performers initiate the independent pursuit of original contributions to the domain. Contrary to Simonton's argument, even within well-defined domains, the highest level of performance is virtually always associated with the creation of new methods and products (Ericsson et al., 1993; Ericsson & Lehmann, 1996). For example, a chess player may propose a new type of variation on an opening or end game, a musician may introduce a different interpretation of a piece, or an athlete may introduce a different technique or training method.

For a long time it was believed that experts acquired a large repertoire of patterns and their superior performance could be attributed to simple pattern matching and recall of previously stored actions from memory in an effortless and automatic manner. However, recent reviews (Ericsson, 1996; Ericsson & Lehmann, 1996) show this view to be, at the very least, incomplete. Superior expert performers in domains such as music, chess, and medicine can generate better actions than their less skilled peers even in situations they have never directly experienced. Expert performers have acquired refined mental representations that maintain access to relevant information about the situation and support more extensive, flexible reasoning to determine the appropriate actions demanded by the encountered situation (Ericsson & Kintsch, 1995). For example, with increased skill, chess players are better able to evaluate relevant aspects of chess positions and use planning to generate superior chess moves (Charness, 1991). Similar evidence for mental representations has been demonstrated for motor-skill experts, such as billiard players when they decide how to make a shot and musicians when they play unfamiliar music for the first time (sight-read). Consequently, the development of reasonably high levels of performance, even in well-defined task domains, involves the acquisition of mental representations and skills to generate and select the better products and better actions under conditions requiring flexibility and creativity. At the highest levels of performance in traditional domains, elite performers have to go beyond the shared knowledge of their competitors in the domain to reach a consistently superior level.

More generally, it is possible to measure the creativity of expert performance by having judges evaluate the experts' behavior, such as their original interpretations of a piece of music or their original, insightful chess moves. But those judgments will by necessity reflect the level of expertise of the evaluators. For example, if the chess-playing skill of the expert judges were below that of the chess player judged, as would be the case for evaluations of a world champion's chess moves, then his or her chess moves would probably appear to be original—and thus unpredictable. Because these moves are likely to lead to a win in the chess match, they would also meet two of the other social-consensus criteria for creativity of ideas (Csikszentmihalyi, 1994).

Creative Domains of Expertise

The expert-performance framework has recently been extended to performance development in creative domains such as the arts and science (Ericsson, 1996, 1998). These accounts focus on the acquisition of mental representations, skills, and knowledge during the decade of preparation prior to the attainment of reproducible high-level performance in both traditional and creative domains. Our knowledge about the development of artistic and scientific achievement (Simonton, 1997) shows that the time course for producing creative products, such as scientific articles, books, paintings, or music compositions, has a uniform shape as a function of the amount of time spent within the domain: Productivity increases dramatically during the first couple of decades of activity in the domain—consistent with the earlier described pattern observed in the traditional domains. The initial lack of productivity for beginners in these creative domains is consistent with the need for training and deliberate practice to reach a sufficient skill level. In fact, basic skills and techniques are as essential for composers, painters, and authors as they are for musicians, athletes, and other performers in the traditional domains. Scientists must master the relevant knowledge and acquire the mental representations that support reasoning before they can develop new ideas. The mental representations necessary to image experiences and the technical skill to translate those images into presentable products is even more essential for composers, painters, and writers (Ericsson, 1996).

When individuals in a creative domain reach the level of independent performers, they are expected to generate creative products, such as paintings, music compositions, or scientific articles. However, the acceptance of these generated products within the domain of expertise is constrained, and the community will carefully evaluate proposed products before they are accepted for appearance in the approved outlets. We are all familiar with reviews and the iterative process of finishing books and articles, but the process is often very similar for painters aspiring to exhibit their art and for composers aspiring to have their music performed. A highly productive creative individual is one who is capable of reliably completing products that meet at least the minimal standards for creativity and technical skill set by the experts in that domain. Simonton's classic finding, that productivity defined as the current production level of satisfactorily creative products is the only reliable predictor of major creative innovations, makes a fair amount of sense within this manner of interpretation.

Scientists and artists cannot fully predict the subsequent evaluation of their creative products and arguments. For example, scientists cannot accurately predict if their preferred theory will be later falsified by experimental findings or if their research proposal will be approved for funding. Similarly, artists have limited means to predict the reception of their latest work by reviewers and potential consumers. An artist or scientist striving to generate as many approved products as possible should strive for minor variations from earlier approved products, because the reception of those minor variations will be much easier to predict than that of highly original products. The more the current product diverges from the status quo, the less relevant information will be available for useful predictions of its subsequent evaluation. Consequently, one would expect great variability in the evaluation of the most original artists. This is consistent with Simonton's finding that eminent creators can produce both a major innovation and one of their least admired products within the same time period—all of them, of course, meeting high standards for technical excellence.

The probability (base rate) for making a truly major innovation is orders of magnitude lower than the probability of making a quality product sufficiently creative to be accepted for public display and incorporation into the accumulated record of the domain. For researchers of creativity, the consistent production of satisfactorily creative products, and the associated mechanisms that make this possible, may provide a path to understanding even major creative innovation (cf. Simonton, 1997).

To understand large individual differences in the production of acceptable but more mundane products, it may be more useful to focus on reasons for an inferior level of productivity. The most obvious reason for low productivity is the lack of sufficient time and motivation to engage full-time in working on products, as well as completing and submitting products for evaluation. There is also the matter of technical proficiency. If the submitted products are poorly generated due to deficient knowledge and skill, the probability of favorable evaluation of even the core concept and its future potential would be reduced. In addition, inadequate knowledge of previous accomplishments in the domain will increase the probability of duplication, thus decreasing the chance that the product will be judged sufficiently creative.

Several factors contribute to individual differences in creative productivity (the rate of completing achievements judged to be creative). Deep knowledge of the domain will allow successful contributors to avoid duplication and to learn from other contributors' failures, thus allowing them to direct their efforts with greater effectiveness. There are also many activities, such as observation of nature and the conduct of scientific experiments, that are known to have successfully stimulated the generation of concepts and products. The processes involved in producing products judged to be original, and thus creative, doesn't have to differ from the processes used by the creator to generate previously created products. In fact, some studies have even claimed to capture the superior ability of authors, painters, and musicians at the expert level to generate creative products under controlled standardized conditions (cf. Getzels & Csikszentmihalyi, 1976; Patrick, 1935, 1937), thus offering the real possibility of experimental studies even of reproducible achievement of products judged to be creative.

In conclusion, some individuals are able to generate products in creative domains of expertise at consistently superior levels that are judged as innovative by experts in the domain. The reproducible quality of their creative production allows us to refer to them as expert performers, as much as if they were concert musicians or world-class chess players. The knowledge and skills mediating this type of superior creative performance appear to reflect acquired mechanisms similar to those identified in other forms of expert performance. Especially at the highest levels of performance, experts in both creative and traditional domains surpass existing boundaries to make creative personal contributions that extend the accumulated knowledge of their domain. Further research on consistently productive scientists and artists is likely to be a very effective approach to uncovering the acquired mechanisms and strategies that underlie innovation at the highest level of performance in more traditional domains. Until the time that empirical evidence compels us to accept important qualitative differences between creative and traditional domains, I will argue for parsimony.

Note

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Is the Theory of Evolution Winning the Battle of the Survival of the Fittest in the Social Sciences?

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Before me sits a stack of books, each written in the last 5 or 6 years, and none of which would have been written 15 years ago. With titles such as *Born to Rebel*, *The Evolution of Desire*, *How the Mind Works*, and *The Adapted Mind*, they portend a powerful change in the way social scientists are doing social science: Darwin, rather than Freud or Skinner, is their starting point. So, while reading the Simonton target article two main questions popped into my head: Are the social sciences headed down the same path as the biological sciences; that is, is the hegemony of the evolutionary perspective inevitable? And second, does Simonton mean his theory metaphorically or literally? Because the main question that Simonton's piece stimulated for me was the more general question of the evolutionary movement in the social sciences, I first briefly review that debate and then move on to Simonton's application of evolutionary theory to creativity.

The Battle for How the Mind Works

Although a serious evolutionary perspective on human behavior began as early as the late 1950s with Chomsky's (1957) work on language and continued in the 1960s and 1970s with psychologists such as Tomkins (1962) and Ekman (1973) and sociobiologists such as E. O. Wilson (1975), it wasn't until the mid- to late 1980s that the movement really became a codified discipline no longer capable of being ignored. Indeed, over the last 10 to 15 years, some would argue that the social sciences in general and psychology in particular have been witness to a belated revolution, most commonly known by the name *evolutionary psychology* (Buss, 1995).

Perhaps the most influential general argument on behalf of evolutionary psychology was put forth by Tooby and Cosmides (1992). Very briefly, they contended that theoretical and empirical advancement in the social sciences has been restricted by the basic assumptions of the standard social science model (SSSM). The most fundamental of these SSSM assumptions is that humans at birth are essentially malleable tabula rasas on which cultural and social values are written and that the cause of complex adult behavior is not the individual, not evolved mechanisms (i.e., human nature) but culture. Philosophically, proponents of the SSSM have their origin in John Locke (1690/1959) when he argued that all knowledge stems from sensory experience. According to proponents of the SSSM, to argue otherwise (i.e., that humans are born with preexisting dispositions and capacities) is tantamount to arguing for genetic determinism and therefore all hope for change is futile. The assumption is that environmental forces can change only things that are not biological, therefore any aspect of human behavior capable of change cannot be biologically based. Moreover, the question then of who or what creates culture is answered circularly: Culture and only culture creates culture. The mind is predisposed to nothing, and culture molds and creates specific people with specific cultural and social values, beliefs, customs, and ways of knowing.

There is one problem with the view that the human mind at birth is completely passive and infinitely moldable and that biological factors are impervious to environmental influence: It is probably wrong. Philosophically, Locke's assertion that nothing is in the mind except sensory information was refuted by Leibniz (1765/1916) as well as with Kant's (1781/1924) notion of a priori structures of the mind. Empirically, there are now thousands of studies in psychology, neuroscience, linguistics, anthropology, and cognitive science that support the evolutionary view that the human brain structure is not vague and general at birth but rather consists of many specific evolved mechanisms designed to solve problems such as spatial ability and mental rotation (Shepard, 1984), emotion recognition (Ekman, 1973, 1994), aesthetic preferences (Barrow, 1995), language acquisition (Chomsky, 1957, 1980; Pinker, 1994), dispositions to respond to novel stimulation (Kagan, 1994), emotional attachments to caregivers (Bowlby, 1982), mate selection (Buss, 1994, 1995), sibling–sibling conflict (Sulloway, 1996), and parenting (Small, 1998).

Now to return to the original question that Simonton's piece provoked in my mind: In 50 years will psychology be monotheoretical, with the evolutionary perspective being the only theory in town? Simonton here and elsewhere is arguing for why an evolutionary perspective should be applied to a process that does mirror evolution itself, namely original and adaptive problem solving (i.e., creativity). Since the 1980s, Simonton has followed in Campbell's footsteps and gradually added to the evolutionary model of creativity, namely that ideas, not just living organisms, are subject to the same principles of natural selection

(Simonton, 1988). Campbell called his version *evolutionary epistemology* whereas Simonton calls his *chance configuration theory* (CCT). The centerpiece of the theory is that creative people are creative because they are ideationally fluent and produce an unusually large number of ideas. Some of these ideas, by chance, are going to cross-pollinate, and therefore certain people are more creative not simply because they have more creative ideas, but because they have more ideas, some of which pass the test of being novel and adaptive—that is, creative. As Simonton has often pointed out, highly creative people also tend to produce many bad (i.e., nonadaptive) ideas, but the proportion of hits to misses stays constant over a lifetime (equal-odds ratio). In the article, Simonton is a bit more confident and bold when it comes to arguing for his theory, as he is ready to pronounce "that the overall creative process must be inherently Darwinian."

One problem I have had with Simonton's theory over the years has been the issue involving volition. I never liked the emphasis on "blind and chance" variation. The implication was that people are creative randomly and by chance. So I was glad to see Simonton address this concern head-on. Indeed, it is the process that is blind, not the person. Insight does consistently happen to certain individuals more than others, and that it does so is not chance. These individuals have the right mix of developmental antecedents (cultural marginality, required expertise), cognitive styles (flexibility, fluency, remote associations, divergent thinking), personality dispositions (openness to experience, independence, nonconformity, hostility, and, in the case of artists, emotional lability), and social influences (social upheaval, nonevaluative environment, cultural heterogeneity, and ideological diversity). When each of these conditions collide in one individual, and when deliberate, conscious, and habitual thought has not led to a "novel and useful" solution to a problem, then this person is primed to take advantage of chance connections among ideas. The creative process may be somewhat blind and chance, but that it so consistently happens to a small proportion of the population and not to others is not chance:

> The individual creator, even the greatest creative genius, cannot simply will discoveries and masterpieces to happen. … Whenever the problem at hand requires genuine creativity, there will be a point where the individual has no other option but to relinquish control to a blind-variation process, such as playful exploration, haphazard tinkering, and free association.

So Simonton is making the argument that Darwin's theory is the best starting point for explaining creativity. Yet to really answer the more general question of how influential will evolutionary theory become in the social sciences, we can either just wait 50 years or we could conduct some sort of trend analysis of the literature and determine both the quantity and the influence (impact) that evolutionary theory is having and how it has changed from 20 years ago. Obviously, we have neither right now and so the question is asked more to stimulate discussion than to provide a definitive answer. An interesting anecdote, however, into this question comes from an article by Kenrick and Simpson (1997), where they reported that the social psychologist Richard Nisbett once thought that each psychology department needed an evolutionary psychologist. Nisbett now believes that each psychologist will either be an evolutionary psychologist or address it in his or her work, much like each biologist does. It may be a bit premature to pronounce evolution the victor in the social sciences, but clearly more and more psychologists are starting with Darwin rather than Freud or Skinner or Bandura. My own prediction is that psychology will never be like biology, with evolutionary theory being the starting point for all psychologists. Psychology as a discipline is more diverse, ranging from the very biological to the very social. There will always be alternatives to Darwin. Yet Darwin will move from being an important theory to some to being perhaps the single most important theory.

I have provided this very brief overview of evolutionary psychology for two reasons: first to address the question of how influential evolutionary theory will become in the social sciences and second as a context from which to evaluate Simonton's chance configuration model of creativity. When compared to the investigations into specific psychologically evolved and adaptive mechanisms such as language acquisition or facial recognition, it is clear that Simonton's use of evolutionary theory in creativity is metaphorical rather than literal.

Literal Versus Metaphorical Darwinism?

Simonton's approach is more metaphorical in that evolution provides a metaphor (through chance mutation and natural selection) for how the creative mind works. Simonton acknowledges this distinction early on in his article. He calls it primary (literal) versus secondary (metaphorical) Darwinism and classifies Campbell's (1960) and his theory as secondary Darwinism.

But the real question is: What happens when we apply more literally evolutionary theory to the creative process? Why is creativity found in the human species and why are some individuals more creative than others? In other words, what are the neurophysiological building blocks (the "architecture of the mind" to use Tooby and Cosmides' 1992 term) that make possible the thought processes such as blind and random associations? In short, why has the human species developed this ability to be creative and why at the individual level is such a small percentage of the human population making creative achievements? When these questions are asked, one could argue that Simonton's theory does not go far enough. Chance configuration may be a useful metaphorical description of the cognitive processes that occur within an individual, but it does not explain how these processes literally evolved in the first place.

True creative achievement is a rather rare trait—only a small percentage of the population makes creative contributions to society. In this sense, it may be similar to physical attractiveness or status, in that only a few individuals possess the ideal expressions of these traits. However, there would be some difficulties with a literal interpretation of Darwin and creativity. Physical attractiveness and status are products of sexual selection insofar as they lead to reproductive success. Creative behavior, in contrast, may well lead to less reproductive success and lower mate values. Being creative, independent, unconventional, hostile, and introverted does not tend to attract others to you. There is, in fact, evidence that creative people tend to be less likely to marry and when they do, have fewer children (Harrison, Moore, & Rucker, 1985; see Storr, 1988). Creative work and love may not be mutually exclusive, but they are adversaries. Yet one could argue that even though being creative may detract from an individual's reproductive success, it nevertheless could add to the overall survivability of the species. Solving problems creatively undoubtedly has contributed to the successful adaptation of the species. In this sense, creativity may be a force that works toward the survival of the species rather than the survival of individuals. To push this speculation even further, perhaps those individuals who do not possess high levels of status or physical attractiveness (i.e., traits that make them attractive to members of the opposite sex) compensate by developing alternative skills such as creative problem solving. Indeed, Freud and Darwin may converge here: Both argued for the primary importance of sex as a motivator of our behavior, and Freud even argued that creativity is sublimated sexual energy. In short, there are two paths to immortality: offspring and creative work. Or, to use one of Freud's more famous phrases, we are talking about the relation and conflict between "work and love." Immortality through one's work is a possible outlet for those who either do not want to achieve or are not successful at achieving immortality through sexual reproduction. Although speculative, these are the sorts of issues that confront a more literal application of Darwin's theory to the study of creative behavior.

Even though Simonton is currently using the theory of evolution metaphorically, he does hint that he is beginning to develop a more literal interpretation. He ends his article suggesting that the metaphorical approach may be subsumed under a more literal primary Darwinian model and cites a recent book in which he makes a more literal application of evolutionary theory.

Chance Configuration and Criteria for a Scientific Theory

Although chance configuration may come up short when compared to literal applications of Darwinian theory to important psychological processes, there are more formal criteria against which to evaluate any scientific theory, namely falsifiability, empirical validity, generation of testable hypotheses, extensivity, and parsimony. How does CCT fare when compared against these criteria?

Falsifiability

As philosophers and scientists since Popper have realized, falsifiability is a rather stringent criterion against which to evaluate a theory. Simply put, a falsifiable theory is one that makes such specific predictions that a crucial experimental outcome to the contrary definitively falsifies the theory. Good theories are never proven, of course; they simply cannot be falsified. Finding evidence consistent with a theory is not enough. It must be directly tested and come away fully intact. By this criterion, the chance configuration model is still wanting. Simonton acknowledges this: "Campbell's model of creativity may lack the falsifiability that Popper (1959) argued was the hallmark of genuine science." He goes on to argue, however, that it serves as a metatheory, stimulating specific models that may be falsifiable. All in all, however, the CCT would rate relatively low on the falsifiable criterion.

Empirical Validity

Falsifiability is a specific form of empirical validity, so how does the chance configuration model do against the more general criterion of empirical validity? Simonton devotes most of the article to addressing this question and divides empirical evidence into three categories: experimental, psychometric, and historiometric. For instance, empirical and anecdotal evidence on incubation serves as the foundation of empirical support for the blind-variation component of the theory. Insight often occurs once conscious, willful thought has exhausted itself on the problem at hand and one focuses on some other problem. Furthermore, there is empirical support for the idea that the most creative among us simply produce a great number of ideas or works, including not very creative ones, which is consistent with the chance configuration model. Research on the personality dispositions of creative people tends to be consistent with the idea that creative solutions to problems are most likely in those who think more fluently and divergently from others: They tend to be independent, nonconforming, and open to experience. Finally, historiometric evidence supports the idea that creative people come from families that are socially, intellectually, and culturally unconventional. Simonton's discussion of each of these areas of evidence is fairly compelling, and therefore the CCT would rate moderately high on empirical validity.

Generates Testable Hypotheses

The theory does a better job of generating testable than falsifiable hypotheses. As Simonton's own voluminous productivity has shown, the theory generates many testable hypotheses, from the relation between age of first work and overall productivity to the ability to have a great number of wide and remote associations, and from the extreme inequitable distribution of creative production in the population to the equal-odds ratio of hits to misses. Simonton's career would suggest a rather fruitful theory, but interestingly relative few of his peers have followed in his and Campbell's footsteps and tested many of the possible hypotheses. The theory would therefore rate medium-high on generating testable hypotheses.

Extensivity

The CCT explains many important aspects of creativity, but not all. It incorporates most of the major domains of psychology: developmental, cognitive, personality, and social. In the target article, Simonton expands the theory to cover elements of clinical-abnormal psychology for the first time when he discusses the connection between creativity and psychopathology. Be this as it may, CCT still does not account very well for all psychological phenomena associated with creativity. For instance, it does not really explain very well other key personality dispositions of creative people, such as hostility, introversion, and lack of warmth. Why should people who are able to generate many original and adaptive ideas be hostile and cold? The theory, therefore, would be rated medium-high on the extensivity criterion.

Parsimony

The theory would be evaluated highly on the parsimony criterion, for it is a rather simple and at times elegant theory. The number of basic assumptions are few, and the overall essence of the theory can be stated rather simply: Creative insight results from a random or chance mental combinatory process, which requires a great many ideas to be generated before novel and adaptive connections are likely to be made. Therefore, the theory would rate high on the parsimony criterion.

As a psychologist who was for a long time not predisposed toward evolutionary explanations, I find this is an interesting time to be working. In graduate school, when I was first exposed to Simonton's theory, I found it quite unappealing, mainly for its emphasis on chance. Now, however, I find myself more sympathetic toward the evolutionary approach. In fact, Simonton's article, if nothing else, forced me to do what most every psychologist is going to have to do at some point, namely confront evolutionary theory directly and think about how it does or does not apply to the particular behaviors they study. We can no longer do what Kenrick and Simpson (1997) recently described in psychology: "These days, to study any animal species while refusing to consider the evolved adaptative significance of their behavior would be considered pure folly. That is, of course, unless the species in question is *Homo sapiens*" (p. 1). So, we must ask: Is human creativity best explained by evolutionary principles? According to Simonton, yes, at least metaphorically. Only time will tell whether a more literal application of Darwin's theory will win the battle for explaining the workings of the creative person, product, and process.

Note

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Was Darwin's Creativity Darwinian?

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When I received the target article by Simonton, I had the following thoughts: "Though our approaches to the study of creativity could not be more different, I am habitually instructed by what he has to say. I've read his new book, *Origins of Genius: Darwinian Perspectives on Creativity* (1999), and so I am familiar with his arguments. Still, it will be interesting to read this short account. I'll put it in my 'travel valise,' and if I have time, I'll read the article. If stimulated, I'll offer a short commentary."

I've read the article, with the following reaction. Inspired by the earlier work of Donald Campbell, Simonton has certainly made a case that much of creativity can be conceived of through a Darwinian lens. Indeed, few parts of the article strike me as wrong and, as always, I've been instructed along the way. Indeed, the article is a *tour de force*. And yet, I find the account curiously incomplete, and I wonder how much our understanding has been enhanced by an account rooted in "blind variation and selection retention."

The problem lies, I think, in Simonton's assumption that all creativity is of the same sort—indeed, that all creativity fundamentally entails the solution of problems. My own studies of extraordinary creators (Gardner, 1993) suggest that there are at least five distinctly separate varieties of creative behavior:

1. The solution of an agreed-upon problem—for example, the determination of the structure of genetic material or how to title an article about creativity.
2. The development of a general comprehensive theory—for example, Darwin's theory of evolution as natural selection, or, for that matter, a theory of creativity.
3. The fashioning of a permanent instance of a genre—for example, the writing of a sonnet or the preparation of an article for a psychology journal.
4. A stylized performance—for example, the conduct of a dance recital or the delivery of a public lecture on creativity.
5. A high-stake performance—for example, the conduct of a military battle or a debate on the nature of creativity conducted in front of the committee that is deciding on the newly created Nobel Prize for the Behavioral Sciences.

Any human behavior or thought pattern (creative or banal) could be described or explained in terms of blind variation and selection. If so, however, the description or explanation is unlikely to be illuminating. Simonton's account gains in power and persuasiveness to the extent that it is particularly useful for understanding the varieties of human creativity.

I suggest that the account is maximally useful when one catches an individual in the throes of trying to solve a problem that has been relatively well defined but whose solution is not yet at hand. The would-be creator is stuck and is casting about for the clues that will advance his or her thinking. Here, the analogy to random mutations, most of which are dysgenic, is not completely far-fetched. When more systematic (rational) approaches or the following of previous models (expertise) do not work, then a process of the sort that Simonton describes may well come into play.

Once one deviates from this "textbook-Graham Wallas style" instance, the application of the Campbell–Simonton model loses its power. The creation of an overall theory involves assembling various parts, filling in a picture, countering alternative theories, determining how best to present an account in a way that is perspicuous and persuasive. This is the task that Charles Darwin confronted and why we honor him rather than Alfred Wallace. The production of a work in a genre entails following the general prescriptions for that genre, with acceptable deviations and transformation for the particular ideas, themes, or occasion. Stylized performances require heightened attention in the moment, with the hope that subtle nuances can be effectively conveyed to a live audience. And in a high-stake performance, one must remain eternally vigilant, lest one's hopes, or even one's life, be ruined.

Certainly, in each of these cases, a measure of creativity is required. However, these latter instances are much better thought of as involving active agents, well aware of what they are trying to achieve, juggling many variables, cognizant of more or less successful models, trying to find the most effective way in which to achieve their goals, making momentary adjustments so that the product is as powerful and convincing as possible (Gruber, 1981; Wallace & Gruber, 1989). Simonton's "individual volition" is the principal operative factor here.

The key difficulty I have with Simonton's account is the implication that blind variation, followed by selection and retention, does much of the work in these instances. True blind variation would imply that the agent, consciously or unconsciously, tries out every conceivable approach or idea in the course of finding an optimal completion of work. I believe that almost the opposite is the case. The mind of the expert creator is so well honed that only an infinitesimal proportion of all conceivable "moves" is considered. Just as the mind of the novice learner has certain biases, based presumably on evolutionary considerations (Barkow, Tooby, & Cosmides, 1992), the mind of the creator automatically eliminates nearly all of the possible but unproductive options. Better to say that we have "extremely constrained variation" followed by "highly reflective selection."

Simonton could retort at this point that the creator is characterized precisely by the fact that he or she considers options that others would not. I would concede the point but insist that it is the creator's expert construal of the problem space that turns attention to surprising (and perhaps effective) options. The nonexpert would not see the power of these options, precisely because he or she is at the mercy of blind variation. The more knowledgeable one is, the less helpful, and the less necessary, a process of blind variation will be. Indeed, I suspect that blind variation takes place when an individual confronts a domain for which human beings have few biases (e.g. understanding macroeconomics) or when an individual reaches a complete impasse in the midst of solving a widely recognized problem (the first of the five instances of creativity cited previously).

Of those five varieties, this commentary is an instance of the third form—preparation of a work in a (relatively) permanent genre (the brief scientific commentary, in the style of *The Behavioral and Brain Sciences*). Without having to wait for the verdict of "the field" (Feldman, Csikszentmihalyi, & Gardner 1994), I am the first to concede that this commentary is not an instance of creativity in the "Big C" sense. At best, it is a humble example of "little C" creativity. Yet I think that reflection on its preparation can be instructive for the point I am trying to make.

I read Simonton's article and found myself in familiar territory. The decision to write the commentary was based on my gradual realization, as I was reading, that Simonton's explanation suited but one of a variety of instances of human creativity. I thought of three or four different ways to make the point and finally decided to use a "self-referential" genre—taking my own writing of a commentary as an (admittedly modest) instance of creative behavior. Selection was certainly at work here, but I find little hint of blind variation—any of us who writes many reviews and commentaries has a preselected set of options, and the primary challenge is "fit" to the topic at hand: the fine-tuning of genre to themes, and themes to genre.

Once I had thought about taking a "self-referential tack"; I then reviewed the various ways in which to incorporate self-reference. For a brief article, the task proved easy—reference to Simonton's article, reference to my own writing of a response, reference to a theory of creativity, and reference to Darwin. Stitching these together constitutes another humble example of creativity—but again, one that is little illuminated by variation, and selection and retention.

As is often the case, I saved until last the choice of title for this article. At first, using a rational analysis of options, I selected the question "Which part of creativity is Darwinian?" as a straightforward title. But then, in the proverbial flash of insight, it occurred to me that the title should make the point of an article in a self-referential way. But how to do this? Being stuck, I did some free-associating and eventually came up with the final title. I am sure that with some effort, I could have come up with a better one, and perhaps, in so doing, provided some support for Simonton's model. But only some…

Note

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Darwinian, Lamarckian, and Rational Creativity

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Simonton's contention that creativity can be explained in a Darwinian fashion offers some exciting possibilities. However, I think that some boundary conditions need to be set. A metaphor, such as secondary Darwinism, can be helpful, but it can also get us in trouble if we follow it too closely. It is generally agreed that a creative idea involves bringing together ideas previously thought to be unrelated. I have elsewhere suggested a connectionist or neural-network model of creativity that has many affinities with the model proposed in the target article (Martindale, 1989, 1995a). A neural network consists of nodes and connections among these nodes. Nodes are entities that behave like neurons but are generally supposed to be made up of a large number of neurons. For a neural network to do anything very useful, one must assume that ideas are distributed. That is, we do not want a node that codes, say, "energy." Rather, we want energy to be coded by a large number of nodes coding the features of this concept. We would never want to say that Einstein connected the energy, mass, and speed of light nodes. Rather, we would want to say that he connected a large number of nodes coding the features of these concepts. We can compare the distributed representations of concepts to genes. Metaphorically, Einstein's equation would be compared with a chromosome and his theory of special relativity to a set of chromosomes. If we wanted to follow the metaphor, the theory in Einstein's brain would be the genotype, and the theory as a published article would be the phenotype. As Simonton hopes, at some time we may be able to reduce creativity from secondary Darwinism to something a lot closer to primary Darwinism.

My argument is that during the preparatory stage of the creative process attention is too focused (Martindale, 1989, 1995a). Worse, it is focused on ideas presumed to be relevant to the problem at hand. Of course, the creative solution will involve ideas thought to be irrelevant to the problem. A trivial problem can be solved at this stage. If a solution is not forthcoming, the problem is set aside. The uncreative person forgets about it altogether. The nodes coding the problem remain primed or partially activated in the fringe of the creative person's awareness during the incubation stage. Now, the creative person goes about his or her daily business. Most stimuli encountered will be random with respect to the problem. However, if a stimulus offers the key to the problem, the nodes coding the problem become fully activated and jump into consciousness. This corresponds to creative inspiration.

An example of this process is how I thought of the theory of aesthetic evolution that Simonton mentions in the target article (Martindale, 1990). I think that the theory is obvious, but a number of people have called it creative. Be this as it may, how did I think of it? As an undergraduate, I took a large number of courses on French literature and noticed that across time the similes and metaphors became more and more remote in French poetry and the content became more primary process in nature. I had some ideas as to why this should be the case, but they weren't satisfactory. The solution came as I was reading an article by Mednick (1958). For reasons I have forgotten, he argued that schizophrenics have avoidance gradients around anxiety words and that these avoidance gradients move outwards across time. Eureka! Poets have avoidance gradients around all words in the poetic lexicon. Once a simile has been used, it can't be used again. To think of more and more remote similes, poets need to regress to more and more primary process levels. Everything fell nicely into place.

Several things should be noted about this example. First, I knew all the components of the theory already. I had just never thought about them at the same time. Second, I wasn't very interested in schizophrenia. Had my attention been too focused on the article, the nodes coding the problem might not have been sufficiently activated. (In a neural network, there is only a finite amount of activation.) Third, let us estimate how many experts on literary history ever read the Mednick article. You might guess 1—me —but my guess would be .5, because I never finished reading the article.

I would argue that perhaps the majority of good ideas occur in the way described previously—trivial normal-science ideas do not, but we don't call these creative. Ideas thought of by invaders from outside a field may not either. Here is an idea that certainly won't win me a Nobel prize but may prevent some others from doing so. A few years ago I came across an article claiming that oligonucleotide sequences of noncoding DNA follow a Zipf distribution. My reaction was on the order of "You idiots, that is a Yule distribution, not a Zipf distribution" (Konopka & Martindale, 1995; Martindale & Konopka, 1996). No flat associative hierarchies or primary process thinking were needed. I just happened to know what the two distributions look like, because I had just written an article showing that literary eminence is described by a Yule rather than a Zipf or Lotka distribution (Martindale, 1995b). Ever since I. A. Richards's (1929) qualitative "experiment" showing that people do not agree as to the meaning of literary texts, literary critics have almost unanimously agreed with this position. By the 1980s, critics such as Fish (1980) were in a frenzy about this. That readers don't agree is absurd. Also, there are a number of reader-reception studies using F tests and t tests showing significant results. What I knew was how to compute reliability or agreement and that none of the experiments would have not been significant were there no agreement among participants. I replicated Richards's experiments and used statistics (Martindale & Dailey, 1995). As had to be the case, people agree quite well as to their interpretation of literary texts. Art critics have been arguing for 200 years as to the existence of cross-media styles. These are styles such as baroque or classic or romantic that are applied to different media such as poetry, painting, music, and architecture. The obvious way to test whether such styles exist is to present naive individuals with examples of such styles in poetry, painting, music, and architecture and see if they sort the exemplars as to style. A graduate student of mine solved this problem in a semester (Hasenfus, Martindale, & Birnbaum, 1983). The point of these examples is that we simply invaded soft disciplines and solved problems because we had better technology or knowledge not possessed by members of the discipline. All that was involved would seem to have been rational problem solving.

Simonton gives a nice account of the birth of creative ideas, but he does not explain the life of ideas. The story of an idea does not stop with its birth. A theory is tested and changed as the results of experiments. Results of experiments can change the "genotype" of the idea considerably. This seems like Larmarckian rather than Darwinian evolution. If the idea is carried over to another generation, we shall have clear evidence for Larmarckian rather than Darwinian evolution. We should consider whether the evolution of ideas is Darwinian or Lamarckian or a combination of both. Because Lamarckian evolution does not hold in biology should not blind us to the fact that it may be a useful concept in psychology.

Note

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Creative Imagination: Evolutionary Theory's Recalcitrant Problem Child

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In putting forward his lucid arguments for an evolutionary model of the individual creation process, artistic as well as scientific creativity, Simonton inadvertently reveals a gaping hole in current theories of mind—that is, a lack of any serious hypotheses concerning the evolution at the species level of that which must lie behind artistic creativity (to which ought certainly be added religious imagination, the creative activity involved in religious behavior). Too often, the evolution of human mind is viewed only as a natural selection process for the development of a fitter animal, better suited for procuring food and for living well and long enough for reproductive success. However, in addition to this "bread and butter" behavior, humans have evolved with "not by bread alone" behavior, much of which may rightly be considered to be creative behavior. This behavior too, although not directly concerned with animal survival and reproduction, must have had some survival value to have been so widely retained.

What, in Darwinian terms, can be the origin of this irrational "problem child" that has developed and flourished in a somewhat well-behaved and potentially predictable world governed by the laws of causality? What cause-and-effect process may have led to imagination? Given all the species in the primate order, what special problem might have caused natural selection to favor this adaptation in just one species? The human creative process also involves rational-intellectual structures and processes. But these are found elsewhere in the animal world (Bronowski, 1977). Human creative imagination, the process of creating objects or events without the benefit of sensory data, is not found elsewhere. Given that, one might guess that the origins of imagination would be a fecund subject for scientific hypothesis. Surprisingly, scientific literature focusing on this subject is virtually nonexistent.

Besides those creative problems with solutions that expand our knowledge of the world and those that serve to provide aesthetic pleasure, there are others, confined to the individual, with solutions that directly do not see the external light of day. Some of these are problems for which logic is all but irrelevant, and the creative solution has little or nothing to do with a tangible product. A person with a life-threatening emotional problem may find a life-saving creative solution. To the rest of the world, nothing may appear to have changed. Such creativity is local and unsung. Emotional problems begin with anxieties, fears, and ill-defined undesirable states, mental states that the burdened party can hardly squeeze into thought, much less into rational communication. A creative solution to such a problem involves some imaginative transformation, via some inspired poet, priest, guru, therapist, or, quite often, the problem-plagued individual alone. The solution for such problems arises from somewhere inside rather than from the external world. It takes the form of some new image or idea that transforms or ameliorates the undesirable and potentially debilitating state.

Most burdensome are apprehensions, "sensing" nonspecific threats, such as the inevitability of death, threats from which there can be no external flight or fight. It seems at least plausible that such problems contributed to the evolution of creative behavior and to the development of artistic and religious, as well as scientific and technical, solutions. My hypothesis suggests the possibility that imagination itself evolved in that process. Pursuing this idea, the findings Simonton summarizes regarding the personality assessment of creative individuals are quite interesting. Not only does this group prove to exhibit more psychopathology than the so-called noncreative, but the match is not the degree of creativity and the degree of psychopathology. Instead, it has more to do with the kind of creative activity; artistic creators being significantly more psychotic than scientific creators. What might we learn from this that relates to the evolution of creative behavior? The artistic creator might likely begin from some internal need and emotional state driving the creative process. The scientific creator might begin the process from some external economic and social need. The artist might be more process oriented, needing the "solution" for his or her own well-being. The scientist might be more goal-oriented, more concerned with the solution serving society, and only indirectly, via reward and praise, serving his or her well-being. If so, this suggests a special role in the evolution of creative behavior for those creators driven by emotional needs.

Here, consider the little we know of the evolutionary roots of creative behavior. Expressions of such behavior are impossible to detect during the long record of *Homo erectus*, with tools and other archeological finds from the period all monotonously unchanged over some 100,000 generations of big-brained and potentially aware creatures who became extinct 200,000 years ago. Mithen (1996), pondering how little *Homo erectus* created, spoke of a "shuffling of the same essential ingredients" in their technology for more than a million years, with only "minor, directionless change" (p. 123).

The oldest archeological evidence for creative behavior is found with *Homo sapiens* some 80,000 years ago. The earliest relevant artifacts, from the late Middle and early Upper Paleolithic periods, express religious activity having to do with death and mortality. The earliest traces of beliefs and practices are of such religious form: Neanderthal burials 70,000 years ago and perhaps even older burials in China; paleolithic cave art drawn in dark, tortuous, difficult-to-access recesses; evidence of animal worship and of rituals associated with hunted animals; and other prehistoric evidence of the struggle to understand and come to terms with individual death and glimmers of mortality (Donald, 1991).

Likely as a by-product of increased intelligence and curiosity, the engine for human creativity started, I suggest, with self-awareness, and then gained momentum with a glimmering awareness of time and mortality. Awareness of a nonspecific danger in the environment, a danger that could not be guarded against by then-existing flight or fight adaptations, would spark a need for some adaptation that could sense a more favorable reality, one beyond the reach of the external senses. Imagination is just that: an adaptation that creates its own reality. The imaginative individual is thus naturally endowed for creativity.

What we normally term *intelligence* or *intellect* can do clever and even new things with the information supplied by the senses. It can interpret the information and apply it to reshape things in nature. In this sense, it creates. But that inner sense known as *imagination* creates something from "material" not found in the external environment. In the face of self and mortality awareness, the driving creative behavior is to engage in what we broadly call "a religious search" to find some meaning in individual existence and some continuity beyond death. The culminating act of this creative search is the imaginative finding of supernatural forces: the creation of spirits and gods with power over human life.

Gods and creation, for all belief systems, go hand in hand. Religious behavior is highly creative: deities and lesser spiritual beings, each with domains and life stories, partly of this world and partly of some creatively imagined world. It seems likely that suspension of disbelief, the creative behavior in processing imaginative literature, originated in processing religious ritual and lore. Mythology was once religious instruction. Religious expression and the poetic are cultural kin. As with poets and other artists, there are highly creative religious figures: prophets and priests whose words and deeds form the bedrock of various cultures.

There appears to be some primal act of creation that every functioning human adult has had to perform throughout his or her life. It involves the creation, so to speak, of imaginative "pockets of immortality," enabling mortally aware individuals to function in relative security from day to day, planning for tomorrow, the next week, month, and year, confident of being alive to execute the planned events. Becker (1973) suggested that the entirety of human psychology is rooted in a massive creative attempt at denial of death. A growing body of terror management theory suggests that an instinctive desire for continued life has led to the creation of elaborate worldviews to manage the "existential terror" brought on by awareness of mortality (Pyszczynski, Greenberg, & Solomon, 1997).

In relation to human phylogenetic processes and cultural change, Lorenz (1973) suggested that behavior patterns and norms of conduct found in all cultures in exactly the same form indicate that they are phylogenetically programmed and genetically specified. Although the content of religions differs from culture to culture, "the behavior patterns and norms" of seeking meaning and continuity in life, and of engaging in a creative search for supersensory powers, seems to be present in all existing cultures, even those practicing Buddhism, in which there is no explicit deity (Brown, 1959). There is a delicious bit of irony in the thought that, in coming to understand the evolution of creative behavior, religion might aid science, that religious behavior might provide a clue to the evolution of imagination.

Note

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Blind Variation or Selective Variation? Evaluative Elements in Creative Thought

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When one mentions the word *creativity*, images come to mind of Einstein and van Gogh. We envision a person who deliberately seeks to solve a problem, such as the nature or portrayal of light, with little regard for approbation and accolades bestowed by others. In his reexamination of Campbell's (1960) theory of blind variation and selective retention, Simonton, in his target article (this issue), makes an articulate scholastic argument for a diametrically opposing view. He argues for a model of creative thought where idea generation is held to be an unstructured, inarticulate process, and evaluation, often social evaluation, is seen as all important in retention of a select subset of ideas from among the many generated. Although this post hoc defense of Campbell's model is intriguing, I find myself troubled by its implications. Are we really to disavow many of the techniques that have proven so successful in the development of creative thinking skills (Basadur, 1997; Bull, Montgomery, & Baloche, 1995)? Are we to assume that the systematic search and testing strategies evidenced by our best scientists are misguided (Feist & Gorman, 1998)? I find these questions troublesome because the description of creative thought and creative achievement provided by Simonton seems at odds with much of what we have learned about creativity over the last two decades. Accordingly, in this commentary, I try to sketch out my objections to this model, considering certain macrotheoretical issues as well as some key findings bearing on the generation and evaluation of new ideas.

Conceptual Issues

As Simonton points out, this Darwinian model of creativity is based on a single, fundamental assumption. More specifically, it holds that creativity ultimately depends on the generation of variations, with the acknowledgment that these variations may be generated under constraints. As Ghiselin (1963) pointed out some years ago, however, creativity is not simply a matter of variation or originality—it also requires usefulness or quality. In other words, creative new ideas must be workable ideas. Given that time and energy are limited, and the potential variations in symbolic systems nearly infinite, the need to produce workable ideas in an efficient manner stresses the importance of the constraints imposed on the generation process. In fact, these constraints may be far more important in understanding creative thought than the production of variations per se. Indeed, most of the recent research on creative thought has focused on the strategies, processes, and cognitive operations that make productive variation possible (e.g., Davidson, 1995; Perkins, 1992). Caution is called for in appraising any theory that relegates such important constraints to the sidelines.

Creative thought, moreover, is a rather subtle and complex phenomenon. This complexity implies that there is not one, or one set, of processes, strategies, and mental operations that ensures creativity across people, problems, and settings. This point is nicely illustrated in a study by Mumford, Costanza, Threlfall, Baughman, and Reiter-Palmon (1993), who asked undergraduates to generate new matrix analogy problems. When they compared individuals with respect to the quality and originality of the resulting products (e.g., production of high-quality, highly original problems vs. low-originality, high-quality problems), they found that some people generated solutions through an extensive associational search whereas others applied controlled search and screening operations. Application of controlled search and screening strategies, moreover, appeared critical to consistent production of original, high-quality solutions, although random associational search seemed sufficient to ensure the production of original solutions.

Not only do these differences observed in strategies and their outcomes indicate the need to consider quality as well as originality in discussions of creative thought, they also bring to the fore an important inferential issue. As I noted previously, creative thought is not a simple, uniform process. Instead, multiple processes, strategies, and mental operations may be involved, applied by different people, in different ways, at different points in a creative effort. When such complex causation exists, and we aggregate data over a variety of problems and settings, we can expect the resulting data to fit a random model. This point is of some importance because it suggests that caution should be exercised whenever aggregate historic data are being used to draw inferences about cognitive operations. More centrally, however, this point implies that inferences about the nature of creative thought, such as universal blind generation, must be made with reference to specific cognitive processes being examined under controlled conditions.

Generation

Simonton does appear to be aware of the fact that an adequate argument for blind generation requires some analysis of the specific cognitive processes involved in producing variations. In fact, he describes two distinct cognitive processes that play a key role in the generation of variations. The first process he proposes is associational linkage, and the second is conceptual combination. The evidence accrued in recent experimental investigations does indeed indicate that people use both these processes in creative problem-solving efforts with associational mechanisms exerting more influence during the early stages of work, whereas the conscious analogical reasoning mechanisms involved in conceptual combination exert more influence in the later stages (Mumford, 1998; Mumford & Gustafson, in press). By the same token, however, it is open to question whether these processes operate in a blind fashion.

Let us begin with the associational process. It is not uncommon to assume, as Simonton does, that associational linkages are based on discrete, happenstance connections. Although this notion may seem appealing at an intuitive level, it ignores the point that associational linkages are embedded in a complex network of connections. As a result, any given stimulus can activate a number of connections, potentially a very large number of connections, many of which are irrelevant to the problem at hand. Thus some mechanism must be used to evaluate the relevance of activated associations. The existence of this evaluative mechanism has been demonstrated in a series of studies by Reiter-Palmon and colleagues (Reiter-Palmon, Mumford, Boes, & Runco, 1997; Reiter-Palmon, Mumford, & Threlfall, 1998). She presented more and less diverse stimuli, defined in terms of problem relevance, and assessed the impact of presentation of these cues on the quality and originality of the solutions obtained to a set of novel problems. As suggested by Simonton, it was found that presentation of more diverse cues did indeed lead to production of higher quality, more original solutions. These effects occurred, however, only when people displayed some skill in constructing or defining the nature of the problem—a finding suggesting that some conscious, evaluative analysis of activated associational linkages may be required. The findings of Getzels and Csikszentmihalyi (1976), Rostan (1994), and Mumford, Reiter-Palmon, and Redmond (1994) also indicate that induction of active analysis, as well as time spent analyzing connections in relation to problem content and available knowledge, are important to the generation of creative solutions. These findings do not seem consistent with the notion that associational linkages are applied blindly.

Turning now to conceptual combination, it is true, as Simonton notes, that presentation of more diverse categories on conceptual combination tasks leads to the production of more original products. The quality of the resulting products, however, may not be especially impressive (Mobley, Doares, & Mumford, 1992). The effects of diversity on quality are not especially surprising given the cognitive operations involved in conceptual combination. Conceptual combination appears to be based on an analogical reasoning process in which people search for and map the common and uncommon features of the categories to be combined using these feature mappings to construct a new category where emergent features and new exemplars are identified through elaboration (Baughman & Mumford, 1995). When the concepts at hand share few features, due to their diversity, quality suffers unless the alternative strategies for finding cross-category relations, such as the use of metaphors, can be applied (Mumford, Baughman, Maher, Costanza, & Supinski, 1997). A similar point was made by Dunbar (1995), who noted that linkage of highly diverse concepts seldom proves useful in the production of creative products in microbiology laboratories. More centrally, however, it appears that conceptual combination is based on the application of conscious, evaluative search and mapping operations.

Taken as a whole, it appears that the key processes identified by Simonton do not imply a blind generation process. Instead, active evaluation and conscious thought appear to be required. Of course associational linkage and conceptual combination are not the only processes that play a role in the generation of new ideas. The problem at hand must be defined, information bearing on the nature of the problem must be gathered, and the concepts to be combined must be selected. What is of note here, however, is that all these processes also seem to involve the kind of evaluation that suggests a directed as opposed to a blind process. An example of this may be seen with information gathering. Mumford, Baughman, Supinski, and Maher (1996) asked undergraduates to produce advertising campaigns for a new product and evaluated the resulting campaigns for quality and originality. They were also asked to work on two problems, one involving management and one involving public policy, where the time spent looking at different types of information was recorded. In keeping with the earlier observations of Davidson and Sternberg (1984) and Kuhn (1970), those who spent time reviewing relevant factual information and anamolous observations were more likely to produce both original and high-quality advertising campaigns than those who spent time reviewing irrelevant or tangential information. In another study, using similar methods, Mumford, Supinski, Threlfall, and Baughman (1996) found that people producing original, high-quality advertising campaigns tended to select concepts consistent with long-term goals. These findings paint a picture of the creative act that reflects an active, evaluative, intellectually intense phenomenon that involves diverse concepts and linkages but where these concepts and linkages are used in a systematic rather than a blind generation process.

Evaluation

Although there seems reason to be skeptical about the notion of blind variation, it is important to remember that Darwinian theory implies a twofold process: blind variation and selective retention. In fact, in the biological sciences identification of plausible selection factors (e.g., predators, niche competition, mate selection, and food supply) represent a minimum condition for making a Darwinian argument. Unless these exogenous selection factors can be identified in a Darwinian system, it is impossible to develop the explanatory models that are the hallmark of true science. The same principal holds in evaluating Simonton's arguments. We need a coherent framework that will allow us to explain why one idea is retained whereas others are rejected. Unfortunately, Simonton does not articulate any systematic mechanisms for the evaluation of new ideas. As a result, caution must be exercised in applying this theory until a reasonably well-developed model of idea selection factors has been proposed.

In fairness, one must remember that this deficiency in Simonton's argument is not unique. Students of creativity have devoted less effort—far less effort—to understanding the social processes and cognitive appraisals involved in the evaluation of new ideas than to understanding how new ideas are generated in the first place (Kasoff, 1995; Runco & Chand, 1994). By the same token, however, it is not immediately apparent how a workable model of idea selection factors can be developed within the model under consideration because, according to Simonton, "It is rare for any major creative product to get a unified response from all pertinent evaluators in a domain. Even worse, the criteria for success are not just inconsistent but unstable besides." Although it is unusual to propose a Darwinian model and disavow the existence of coherent selection factors, this approach is integral to a number of Simonton's other arguments. One example may be found in his argument that the randomness of evaluation minimizes the relevance of expertise to creative thought. Another example may be found in his argument that the complex, inextricable factors influencing evaluation are beyond the capacity of people to cope with in generating ideas. Thus blind evaluation is used as a justification for blind generation—a logic that immediately strikes one as inherently circular.

It is open to question whether these assumptions about the evaluation of new ideas hold true. Runco and Chand (1994) showed that people are capable of identifying and distinguishing among popular and creative ideas. As people acquire expertise in a field, one sees substantially more agreement in their evaluations of quality and originality (Mumford, 1995). This observation is consistent with the finding that well-developed rating scales for appraising quality and originality, when applied by trained judges, typically yield interrater agreement coefficients in the .80s (Hennessey & Amabile, 1988; Redmond, Mumford, & Teach, 1993). In other words, creativity may be complex, but there are some common systematic factors that influence evaluation, factors that may well make it possible for people, particularly experts, to guide their efforts toward the achievement of certain goals.

In complex social systems, it is difficult to see how any creative idea could be turned into a viable product if there was not a systematic component to the evaluation of new ideas. To turn a new idea into a product, such as the Mars lander, resources must be required, support must be obtained from those who will work out the details of implementation, and organizational procedures must be adjusted to accommodate the innovation (Damanpour, 1991; Dougherty & Hardy, 1996). In deciding whether to make this kind of investment in a proposed new idea, organizations consider a rather coherent set of evaluation criteria, including potential gains in efficiency, compatibility with existing systems, ease of implementation, and potential strategic contributions (Rodgers & Adhikurya, 1979; Tushman, 1997). Not only are these standards known, there is good reason to suspect that they are actively considered in the idea generation process (Hounshell, 1992). Of course, one might argue that these standards only apply to technical innovation, having little relevance to the more rarified world of the arts and pure science. However, as Holyoak and Thagard (1997) showed, evaluative standards can be applied even in the most abstract types of analogical reasoning by considering factors such as coherence, completeness, and explanatory power. Although the complex nature of these standards may, as suggested by Simonton, prohibit constant ongoing consideration of evaluative standards in creative thought, it does not preclude the kind of cycles of generation and evaluation suggested by Basadur (1995) as people work through the novel problems that call for creative thought.

Conclusions

In this reexamination of Campbell's (1960) blind variation and selective retention model, Simonton has asked us to reevaluate a potentially promising idea. At this juncture, it would therefore seem appropriate to ask how this model stacks up against the kind of evaluation standards sketched out in this article. As presented in Simonton's target article, this model seems to me incomplete, because it lacks the detailed analysis of selection factors needed to appraise a Darwinian model. To make matters worse, I am not sure that the investment of effort needed to identify these evaluation factors would prove fruitful because there is little evidence in the cognitive literature indicating that the key processes involved in creative thought operate in a blind fashion.

This conclusion, however, poses a final, somewhat more speculative, question. Why, given the available research on creative thought, do many of us still find the notion of blind variation so attractive? This question becomes more pressing when it is recognized that many of the attempts to apply blind variation models in enhancing creativity have not proven overly successful, nor especially productive, with respect to our theoretical understanding of the creative act. My only real answer to this question is that the open, free, playful description of the creative process provided by this model is an attractive description—one that is more attractive than models that call for extended search, careful analysis of relations, and a progressive, often frustrating, elaboration, refinement, and implementation process. Nonetheless, it is only by coming to grips with the complexity and difficulty of creative thought that we can make a real, practical contribution to the capacity of people to generate new ideas.

Notes

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How Cheetah Writes *Hamlet*

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A classic example from combinatorics asks about the likelihood of a monkey writing *Hamlet* by typing randomly on a typewriter. The probability turns out to be exceedingly low. A legion of monkeys typing a character a second would have virtually no chance of producing *Hamlet* before the death of the universe.

The case of the monkeys is an extreme version of the insight that good combinations do not conveniently fall into place. Accordingly, Donald Campbell's proposition that human productivity depends ultimately on blind variation and selective retention (BVSR) and Dean Keith Simonton's target article (this issue) advancing and extending his claim carry the shock of implausibility (Campbell, 1960; also see Cziko, 1995). Even with Shakespeare behind the quill rather than Cheetah behind the keyboard, we are supposed to believe that *Hamlet* got written by monkeying around.

Still, there is good reason why we should. Evolutionists have invested considerable thought to explain how biological evolution manages to accomplish so much by rolling dice (e.g. Dawkins, 1987). In the psychological realm, Campbell (1960) offered a range of arguments and explanations, and Simonton's article assembles a compelling range of empirical evidence for the presence of BVSR in human creativity. I would like to add to this in two ways: (a) argue in the spirit of Campbell that the conclusion is fundamentally logically inevitable, although empirical corroboration is welcome, and (b) urge that it's not enough to acknowledge the inevitable role of BVSR. We need to understand how it accomplishes as much as it does. If monkeying around and lucking out are at the heart of creativity, how do human beings—or biological evolution for that matter—"up luck" enough to produce something worthwhile?

The Inevitable Need to Luck Out

By definition, creativity involves producing something that is unexpected but works. If the something were expected, it would not count as creative, and neither would it if it were unexpected but did not work. Of course, "works" is context relative, meaning that the something proves compelling as artistic expression, effective as an invention, powerful as a theory, or whatever canon applies.

If a mechanism were to create something without BVSR, by definition it would need to compose this something with little trial and error. It would need to produce (a) something outside its "expectations"—not necessarily explicit expectations but at least embodied in its methods of construction—but (b) something that nonetheless does work with high probability. Clearly this is contradictory. The embodied expectations reflect a model of what it takes to make the something work. If the mechanism abandons that model, what it concocts cannot be a good bet by the measure of those expectations. To function creatively, the mechanism has to abandon its embodied sense of what is expected to work and monkey around, producing things that are higher risk but might turn out to work after all. The hit rate will be much lower, but the results when they occur much more surprising. Thus BVSR plays a logically inevitable role in creativity. Only when we surprise ourselves is creativity truly at work.

Upping Luck With Embodied Knowledge

If lucking out is necessary for true creativity, the question remains how to luck out with acceptable efficiency. The general solution offered by Campbell (1960) and Simonton is that the quest must embody knowledge of the world. Shakespeare may have done some monkeying around, but not like Cheetah. Shakespeare's search for a truly creative phrase, one that would surprise even him, would be blind in the sense that he would generate phrases he would then have to assess for their suitability. However, they would be good-bet phrases. Shakespeare would focus on tropes such as metaphor or synecdoche likely to generate a striking phrase and would travel along paths of semantic transformation such as irony or exaggeration that often yield impact.

This knowledge of the world of words, or other worlds that creative individuals search, was captured through earlier processes of BVSR at various levels and on various time scales: Shakespeare's personal development as a writer, the development of Elizabethan literary practices, the development of the English language itself, the evolution of biologically based language capacities in human beings, and so on.

Three Ways of Upping Luck

This broad picture does not say much about how the process of embodying knowledge works in detail. In previous writings, I have discussed three general mechanisms that explain how knowledge gets embodied, not only in human minds and cultures but in other systems as well: adaptation by BVSR, adaptation by revision, and adaptation through plans (Perkins, 1998, in press).

Adaptation by revision and adaptation through plans are mechanisms originally produced by BVSR, but they move away from it in certain ways. Adaptation by revision is direct adaptation in response to a situation. For example, Shakespeare notes a forced rhyme and substitutes another, a wolf runs long hours pursuing caribou and its musculature and breathing apparatus develop to cope with the stress better, or a self-sealing automobile tire automatically seals a puncture, an adaptive capacity built in by the human designer. In contrast with BVSR, there is little or no search.

Adaptation through plans involves either BVSR or adaptation by revision, but operating on a plan or representation or recipe for the ultimate product, rather than just the product itself. Thus Shakespeare might make and revise an outline before writing the whole play, and thus mutation and crossover occur at the level of DNA—a recipe for an organism.

Each of these three mechanisms embodies domain knowledge to up the luck of the system generating a product. BVSR typically embodies domain knowledge both in variation and in selection. Variation produces candidate outcomes that are "in the ballpark" of viability, but what will prove viable remains for selection to decide. Selection embodies knowledge when, for instance, Shakespeare uses himself as a model of his audience, saying to himself "This will play well, that won't," or when developers of new antibiotics test them on animals as a preliminary screening toward the human case.

Adaptation by revision embodies highly specific knowledge of successful responses, captured from prior individual experience and cultural and biological evolution. For the most part, when a rhyme is forced, the right thing to do is change it; when a muscle is stressed, the right thing to do is strengthen it. Adaptation through plans embodies knowledge of the ultimate world of products (plays, works of art, scientific theories, etc.) in a "planning space," (cf. Newell & Simon, 1972) that captures some of the important features of that ultimate world. By conducting part of the search in the planning space, the search mechanism reduces energy expenditure and avoids catastrophic failures. Thus we test new wing designs in wind tunnels and on prototype aircraft before they appear on commercial airlines.

How General Strategies Up Luck

More than domain expertise is involved in the three mechanisms. Each mechanism also makes room for broad strategies. For example, BVSR in simple forms is prone to the problem of local maxima, as it's called in the field of artificial intelligence. A search process governed by BVSR may perseverate in the neighborhood of a not-quite-adequate solution. Although the better solutions lie further afield, the search mechanism never reaches them because it turns back, discouraged by dropping viability. A smarter search process recognizes when it's reworking the same territory with inadequate results and adopts a more divergent strategy. Even genetic processes do something of the sort. As Simonton notes, under stress conditions, some bacteria produce a wider range of variations—genetic brainstorming. Wesson (1991) discussed this and various other evolutionary tricks that make evolution "smart" (see also Perkins, 1994).

Likewise, adaptation by revision can be more or less smart in a general strategic way. A revision is a good-bet adjustment, far from blind but not necessarily perfectly reliable. Accordingly, one important strategic consideration is whether the adjustment is reversible. If not, it's best taken more cautiously. Watercolor artists have to be more careful than oil painters, and parachuters do well to arrange their equipment more carefully than picnickers.

As to adaptation through plans, here too rather general strategies can make the process smarter. One major factor concerns whether testing the plan occurs primarily in the planning space or in the space of the ultimate product. Evolution constructs its plans in the planning space of DNA, tests them for minimal viability during developmental processes such as gestation, and submits them for ultimate approval in the real environment. In many processes of human creativity, far more testing occurs within the planning space, as when artists explore alternative sketches before ever picking up the paints, or engineers run computer simulations before ever building a prototype.

Evolution's Monkey

All three of the identified mechanisms figure conspicuously in play in human invention, from Shakespeare to Einstein to Picasso, operating only with extensive domain knowledge but in highly strategic ways. If human creators do sophisticated monkeying around, it's worth asking how sophisticated the process of biological evolution is. Campbell (1960) and Simonton take care to point out that they are not arguing that human invention functions just like biological evolution. Still, it's worth underscoring the sharp contrasts between BVSR in biological evolution and human creation (Perkins, 1994).

The three mechanisms already introduced provide a convenient way to chart the contrasts. Regarding the process of BVSR, a major limitation of natural selection is that the process must function entirely through viable products—organisms that actually survive and mature to reproduce. In contrast, an engineer may produce a prototype that is an utter failure but go on from there to make a further variation of it work. Evolution has no way to do this. On the other hand, evolution benefits from massive parallel processing over geological time—innumerable trials over countless generations.

The process of natural selection makes very limited use of adaptation by revision, a mainstay of human productivity. At the level of DNA, there are processes of gene repair that accomplish adjustments for low-level anomalies. However, once a mature living organism emerges, revisions in the organism—for instance, strengthening or learning—are not translated back into the genetic structure, with a few esoteric exceptions (Jablonka & Lamb, 1995).

Adaptation through plans plays a central role in natural selection, of course. New organisms emerge as mutations, and crossovers produce new plans for organisms at the level of DNA. However, the system is strictly a two-tier one, far from the multiple tiers of human creativity, where one may have an idea for a plan for a mock-up for a prototype for a final product. Moreover, as underscored earlier, selection occurs primarily at the product level—a high investment in an actual living organism—rather than at the low-investment plan level.

In summary, it is sound and important to say that all human creativity and a good many other productive processes depend fundamentally on BVSR—monkeying around. At the same time, the universality of monkeying around does not mean that all monkeying around is alike. Especially lucky monkeys monkey around not only in more domain-knowledgeable ways but in more strategic ways. Not only the necessity of lucking out but the mechanisms for upping luck need to be appreciated if we are to understand how BVSR accomplishes what it does before the end of the universe.

Note

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Why Creativity Is Not Like the Proverbial Typing Monkey

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It is sometimes claimed that if one were to give an immortal monkey a typewriter, infinite time, and endless patience, it would eventually produce the entire works of Shakespeare (and all other creative products for that matter). In certain key respects, the notion of a tireless typing monkey is analogous to idea generation in a Darwinian theory of creativity. Specifically, according to this view (e.g., Campbell, 1960; Simonton, this issue), creative products result from the interplay between a blind variation process (that leads to idea generation and variation) and natural selection processes (that sort them out). Although this analysis provides a systematic method for favoring stronger products over weaker ones, the assumption that the creative process results from blind variation and random mutation is ultimately akin to viewing creativity as resulting from tireless typing monkeys. Critically, however, in contrast to the proverbial typing monkey, people do not have infinite time in which to generate their creative products. As a consequence of the time constraints inherent in a truly random search process, it follows on a priori grounds alone that creativity must rely on some type of directive and narrowing processes to guide creators in fruitful directions (Sternberg, 1998). Moreover, when we investigate the cognitive processes known and hypothesized to lead to creative products, it becomes increasingly clear that creativity is not blind. This is not to say that there are no random, or at least quasi-random, processes involved in creativity. However, even a brief consideration of the empirical evidence and logical arguments on this topic suggests that creativity cannot be adequately accounted for by nonguided processes such as those suggested by analogies to blind variation, random mutation, or diligent typing monkeys.

Evidence That Creativity Is Guided

In his classic treatise on tacit knowledge the philosopher Polanyi (1967) suggested that scientists and other investigators rely on "intimations of something hidden, which we may yet discover" (pp. 22–23) to guide them in fruitful directions. Indeed, Polanyi suggested that this ability to anticipate, without fully conceptualizing, future discoveries is the quintessential skill involved in creative scientific investigation. As Polanyi put it: "We must conclude that the paradigmatic case of scientific knowledge, in which all faculties that are necessary for finding and holding scientific knowledge are fully developed, is the knowledge of an approaching discovery" (pp. 24–25). Indeed, many scientists have acknowledged relying on such anticipatory hunches in pursuing their scientific ideas. As the Nobel Laureate in medicine Michael Brown observed: "As we did our work, we felt at times that there was almost a hand guiding us. Because we would go from one step to the next, and somehow we would know which was the right way to go. And I really can't tell how we knew that" (cited in Claxton, 1998, p. 57). The Nobel Laureate Stanley Cohen similarly commented on the importance of developing a "nose" for anticipating promising directions, noting "I am not always right, but I do have feelings about what is an important observation and what is probably trivial" (cited in Claxton, 1998, p. 57).

Although creative individuals often report the phenomenological experience of being able to sense promising directions, it is of course possible that such accounts are simply artifacts of hindsight, (i.e., individuals could preferentially recall the cases in which their "hunches" were correct). However, laboratory research similarly indicates that individuals are capable of anticipating what problems may lead to creative solutions, prior to actually solving the problems. For example, in one series of studies, Bowers, Regehr, Balthazard, and Parker (1990) used a "remote associate" paradigm (Mednick & Mednick, 1967) in which individuals see three-word triads (e.g., playing, credit, report) and must identify a single word corresponding to all three (e.g., card). In the Bowers et al. paradigm, individuals were simultaneously given two triads, only one of which had a solution. Bowers et al. found that individuals were above chance at guessing which triad had a solution even if they could not solve it. Bowers et al. found similar evidence for anticipatory hunches using a variety of other paradigms. For example, participants were above chance at anticipating which of several degraded pictures were likely to reveal an actual image when they became more in focus. In short, Bowers's findings empirically support Polanyi's notion that individuals can anticipate what problems or directions are likely to lead to creative solutions even if they are presently unaware of what those solutions are likely to be (see also Bowers, Farvolden, & Mermigis, 1995).

Although Bowers et al.'s (1990) evidence for the robustness of anticipatory hunches is striking, in retrospect it should really not be all that surprising. In addition to being supported by both philosophical speculations and anecdotal reports, it is also entirely consistent with the basic cognitive notion of spreading activation. According to spreading activation theories (e.g., Anderson, 1990; Collins & Loftus, 1975), the activation of concepts in memory results in the spread of activation to related concepts. This basic spreading activation process serves as a powerful potential mechanism for how systematic yet nonconscious processes could lead to successful solutions (e.g., Langley & Jones, 1988; Ohlsson, 1992; Schooler, Ohlsson, & Brooks, 1993; Yaniv & Meyer, 1987). Accordingly, while working on a problem subconscious activation may spread to related relevant operators. The accumulation of such activation may initially give individuals the sense of promising directions (i.e., the anticipatory hunches suggested by Polanyi, 1967, and demonstrated by Bowers et al., 1990). Subsequent accumulation of additional activation through either further elaboration of the problem or the encountering of new information in the environment may ultimately raise the activation level of critical operators above the threshold of awareness, thereby leading to a solution.

Although these processes are not hypothesized to be under deliberate control, they are by no means random in nature. Rather, the direction and extent of the spread of activation critically depends on (a) the specific items that were initially activated and (b) the underlying structure of an individual's knowledge representation. The importance of these two factors in the ultimate discovery of a solution further helps to account for why individuals differ in their ability to reach creative solutions. How activation initially spreads will be influenced by the manner in which the problem is initially defined. Considerable research suggests that expert problem solvers are far more proficient than novices in characterizing problems in terms of their abstract deep structure properties (e.g., Chi, Feltovitch, & Glaser, 1981). Presumably, according to this approach, one advantage of such an initial characterization is that it allows activation to spread to relevant operators that may share little in the way of surface structure similarity with the initial problem. In short, such an initial problem elaboration could lead to the retrieval of distant relevant associations, one of the hallmarks of significant creative solutions. In addition to possessing superior initial elaboration strategies, experts also have more elaborated and organized knowledge representations, which according to standard spreading activation models (Anderson, 1990) should lead to faster and further spreading of activation, thereby further facilitating the retrieval of distant associations. In addition to accounting for the common benefits of expertise in reaching creative solutions, a nonrandom spreading activation model of creativity can also help account for situations in which expertise can be harmful, that is, when standard problem approaches do not work. Accordingly, with practice certain activation paths are particularly likely to be followed. If such paths are viable then this is a beneficial quality. If, however, particular cases arise in which such paths are "off the track," then experts may be especially misled (cf. Wiley, 1998).

In his original postulation of the random processes that lead to the natural selection of creative ideas, Campbell (1960) drew heavily on the introspective reports of creative individuals such as the mathematician Poincaré. Poincaré (cited by Koestler, 1964) suggested that during incubation, ideas may recombine like atoms that have become unhooked from a wall: "During a period of apparent rest and unconscious work certain of them are detached from the wall and put into motion. They flash in every direction through space… then their mutual impacts may produce new combinations" (p. 165). Although such phenomenological accounts nicely capture the random creativity processes hypothesized by Campbell (1960) and others, they are also generally compatible with a spreading activation account of creativity, with one critical caveat: The recombination processes are not entirely random but rather follow systematic routes resulting from the intersecting paths of spreading activation. Importantly, although systematic, these intersections may nevertheless span seemingly large gulfs, especially if individuals define problems according to their deep structure properties and if their knowledge representations are themselves organized in novel ways.

The Role of Random Processes in Creativity

The previous analysis strongly suggests that even seemingly unconscious incubation processes may be influenced by nonrandom directed processes that often (although not invariably) facilitate successful solutions. Nevertheless, there is still room to include some form of random or semirandom processes. For one, the environment itself, although often powerfully influenced by the strategies of the would-be creator, certainly introduces entirely unexpected twists and turns. Such random information could well serve as a useful catalyst for directing further routing of spreading activation processes that could lead to originally unanticipated solutions. Nevertheless, as the biologist Louis Pasteur aptly noted, "chance favors the prepared mind" (cited by Posner, 1973). In an especially compelling discussion, Seifert, Meyer, Davidson, Patalona, and Yaniv (1995) considered the processes by which individuals may come to be prepared to benefit from encountering serendipitous events in the environment. According to Seifert et al., when individuals reach an impasse on a problem they formulate special markers termed *failure indices* that remain active and ever vigilant for the sought-after information. If critical information is happened on that corresponds to the open failure indexes, its match is recognized and the sought-after solution is suddenly realized. This account nicely explains why "Eureka" experiences often occur when the problem is not directly in mind; that is, presumably some cue in the environment is encountered that fits the previously established failure indices. It also explains the counterintuitive Zeigarnick effect whereby individuals retain superior memory for unsolved problems; an open impasse index maintains the activation of the problem. Most important to this discussion, however, is that such a process simultaneously illustrates the complimentary roles of directed and random processes in creative discoveries. Whereas some random processes contribute to whether the appropriate solution cue is encountered, the ultimate reconciliation of an impasse index must critically depend on how the failure was initially encoded. If the initial impasse is defined in a superficial or shortsighted way, then it seems inconceivable that the system would be sensitive to a remote clue to a solution that was randomly stumbled on in the environment. If however, the impasse was defined in a well-specified but nevertheless abstract manner, then it could be potentially much more sensitive to recognizing solutions that might otherwise have been overlooked. In short, when we consider the basic cognitive processes that would enable an individual to benefit from random inputs from the environment, the critical importance of nonrandom foresight in the initial formulation of a problem becomes evident.

In addition to random inputs from the environment, it also seems quite plausible that random or quasi-random internal psychological processes could also contribute to the variations that lead to creative processes. Neural noise, spurious associations, and even potentially the chaotic processes inherent in complexity (Gleick, 1987) could all be potentially useful sources of variation. Critically, however, the outcome of such random internal events will, arguably by necessity, depend fundamentally on the preparedness and skill of the would-be creator to take advantage of such fluctuations. Whereas random neural activity presumably occurs in us all, only a very select few are able to produce truly creative products.

Accounting for Findings Purported to Support Blind Variation

In arguing that creativity primarily relies on nonrandom processes associated with knowledge organization, problem definition, and spreading activation, we necessarily must account for the various findings that have been characterized as supporting a blind variation process. We have already reviewed our account of a number of such findings, including the formulation of truly novel creations (resulting from abstract problem definition and unusual knowledge organization); the benefits of incubation (as resulting from intersection of paths of spreading activation); and the benefits of serendipitous cues from the environment (resulting from an optimal initial formulation of a problem impasse). However, there are several other key creativity findings that need to be grappled with.

The Beneficial Effects of Random Stimulation

Simonton notes a variety of paradigms in which encountering random variations leads to the production of superior products. For example, Finke, Ward, and Smith (1992) found that individuals generate more creative inventions when they are given randomly selected parts rather than being allowed to choose the parts themselves. Similarly, Rothenberg (1986) found that exposing artists to ambiguous juxtapositions of incongruous images increases the creativity of their subsequently generated drawings. Although such findings do indeed reveal the value of random input to the creative process, they do not necessarily indicate that the creative process itself is random. To the contrary, in fact, such findings suggest that the creative process is inherently structured, indeed often too structured. Accordingly, when given creative tasks, the majority of individuals may naturally follow familiar routes, as would be expected by any theory of spreading activation. However, when divergent information is encountered, less traveled patterns of activation are likely to be triggered, resulting in more novel products. Again this analysis highlights the fact that just because creativity can be fostered by random cues does not necessarily implicate randomness in the psychological process of creativity.

The Relation Between Creativity and Psychopathology

Simonton and others have argued that the frequently noted positive relation between creativity and psychopathology provides further fodder for the role of random variation in fostering creative products. As Simonton observes, modest degrees of psychopathology produce an "ideal situation for the production of ideational mutations." It stands to reason that a willingness or propensity to defy convention (which is the hallmark of psychopathological scales that have been associated with creativity; e.g., Eysenck, 1994) would facilitate individuals' ability to generate novel solutions. Nevertheless, it does not necessarily follow that the creative process of such individuals is itself random. A spreading activation account of creativity can readily accommodate the association between creativity and psychopathology without assuming that psychopathological individuals necessarily rely on entirely random associations.

First, given their nonconformist tendencies, it follows that certain psychopathologies could lead to unique knowledge organizations that would in turn enable activation to spread in atypical ways. Second, there is some evidence that certain psychopathologies (e.g., schizoid tendencies) may also alter the extent of the spread of activation. For example, Spitzer, Braun, Hermle, and Maier (1993) found that compared to healthy controls, thought-disordered schizophrenics were more likely to reveal semantic priming effects with indirect associations (e.g., chalk–(white)–black) in which the connection between a word pair (e.g., chalk–black) is obvious only via a mediating associated word (white). Accordingly, the word *chalk* was more likely to prime (reduce lexical decision time) the word *black* for schizophrenics relative to controls. This finding was accounted for on the assumption that "semantic associations spread further and faster in thought disordered schizophrenic patients than in normal controls" (Spitzer et al., 1995, p. 864). Thus the association between psychopathology and creativity need not result from greater tendency for entirely random associations. Rather, the advantage that some (although clearly not all) psychopathological individuals may show in creativity may result because their spreading activation systems enable the intersections of activation between more distant (but still indirectly connected) associations.

The Equal-Odds Rule

One of the most compelling sources of evidence for a random variation account of creativity comes from what Simonton has termed *the equal-odds rule*. The equal-odds rule describes the finding that the ratio of exceptional products to total created products randomly fluctuates over time. Although individuals typically increase and then ultimately decrease in productivity (leading to certain times in which their best products are most likely to be created), the average proportion of hits to duds remains constant throughout a career. The basic logic of this argument for random variation is that under the assumption that creativity is guided, the average ratio of exceptional products (e.g., hits) to weak products (e.g., duds) should increase as a function of experience (or other variables). However, this is not found: The average proportion of hits to duds remains constant throughout a career. Simonton describes the essence of this argument: "if the variation process is truly blind, then good and bad ideas should appear more or less randomly across careers, just as happens for genetic mutations and recombinations."

The claim that the equal-odds rule suggests that creativity results from random processes relies on the assumption that nonrandom creativity processes should lead to systematic changes in the quality of output over a career. However, when we consider the specific nonrandom processes that might influence the ratio of hits to duds over a career, it is not at all self-evident that such processes should necessarily lead to systematic changes, particularly when aggregated across individuals. This can be seen when we consider two basic components that are likely to influence the hit to dud ratio: changes in idea generation and changes in idea promotion.

First, consider the process of idea generation. It seems quite reasonable that with experience a given individual's ability to generate creative ideas may change. However, it is less clear that the net result of such changes should lead to systematic variations in the quality of products across individuals. For example, some individuals may be especially able to draw on fluid intelligence skills, which are known to be maximized at relatively early ages, thereby producing their best products at an early age. Other individuals may rely on more crystallized intelligence, which continues to develop with age, producing their best products at a later age (Horn & Cattell, 1967). Still others may initially rely on one type of intelligence and then compensate with the other as they age (thereby maintaining constant quality throughout). When aggregated across individuals (as is done in Simonton's historiometric analyses), such changes should not necessarily lead to systematic differences in the quality of products over careers. That is, the systematic variations are likely to be bidirectional, and consequently the effects of the variations may simply cancel each other out.

Next, consider the notion of idea promotion. It seems reasonable to assume that the criteria for how good an idea must be to pursue it will fluctuate over the course of a career. For example, some individuals may become increasingly capable of determining which are the best ideas to invest time in. Others, however, having become increasingly facile in turning their ideas into products, may become more lenient in their standards over time. (We certainly all know individuals who, as their careers progress, are invited to write more and more chapters and agree to do so regardless of whether they have anything new to say.) As with the notion of idea generation, the bidirectional changes in idea promotion as a function of time may cancel out when aggregated across individuals.

In short, there clearly are factors that will influence the hit-to-dud idea ratio over a career, and such factors arguably work in opposition over time (i.e., some increase the hit-to-dud ratio and others decrease it). Thus it seems quite plausible that such factors could cancel each other out when analyses are aggregated across individuals. Importantly, this interpretation of the equal-odds rule avoids the rather dubious assumption of the random variation approach that individuals fail to develop the capacity for recognizing quality. Simonton argues that the capriciousness of the environment prevents experts from anticipating what products will be successful: “There are simply too many relevant factors, participating in intricate curvilinear and multiplicative relations, for anyone, including the creator, to discern why one product hits whereas another misses.” However, it is clear that this claim is vastly overstated. Although none of us are prophets, certain ideas are self-evident and immediately noteworthy. In all likelihood, Edison appreciated the unique importance of the light bulb over some of his lesser inventions. It may simply have been that once an idea occurred to him that was above some acceptability criteria, great or merely good, he was compelled to pursue it. Similarly, just because Shakespeare published many works does not mean that he held them all in equal esteem and was incapable of estimating (to some extent at least) those that were the most momentous. We cannot and should not use individuals’ willingness to promote ideas as evidence that they are incapable of distinguishing between them. Thus the fact that individuals continue to promote their lesser works as their careers progress probably speaks more to their increased opportunities than it does to their absence of developing a sense of what is really good.

Creative Vision

There is a certain irony in referring to creativity as inherently blind given that creativity is traditionally, at least, thought of in terms of the antithetical construct of vision. The term *insight* itself emphasizes its parallels with vision, as do other common characterizations of insight such as “a sudden flash,” “a moment of illumination,” or “seeing the light.” We speak of creative individuals as “visionaries,” as possessing “creative vision,” and of uniquely “seeing into” a problem. In addition to permeating our folk metaphors, the analogy between creativity and vision pervades scientific characterizations of creativity. Gestalt psychologists, who studied creativity during a time when few others did, characterized creative insight processes as relying on many of the same principles of “good form,” such as closure, used to account for perception. In a similar vein, Ellen (1982) suggested that insight is akin to Gestalt classic figure ground reversals (e.g., the necker cubes) in which individuals can suddenly recognize a fundamentally different image. Other researchers who have emphasized the parallel between creativity and vision include Ohlsson (1984), who discussed creative discoveries as occurring when the solution appears in “the horizon of mental lookahead” (p. 117). Indeed, even Simonton (1995) at least tacitly used a vision metaphor in talking about creativity, suggesting that creative discoveries occur when consciousness is able to “suddenly change focus, and spotlight the discovery” (p. 477).

Further evidence for a meaningful relation between vision and creativity comes from the striking parallels between creative discoveries and the perceptual identification of degraded images (Schooler, Fallshore, & Fiore, 1995; Schooler & Melcher, 1995). Like insights, recognition of degraded pictures (e.g., out-of-focus photos or fragmented drawings) can be hampered by mental sets (e.g., Bruner & Potter, 1964) that can result from initially generating incorrect hypotheses. Moreover, apprehension of the contents of a degraded image shares much of the phenomenology with the subjective “Aha!” experience of a conceptual discovery. The perceiver experiences a sudden shift from an absence of any (explicit) sense of what is depicted to a full identification of the picture’s contents and configural properties. In short, one experiences a sense of “now I see it where I didn’t a moment before” that parallels the “Aha!” experiences of creative discoveries that have been documented both anecdotally and empirically. In addition to the parallels in process and phenomenology, the identification of degraded pictures has also been shown to draw on some of the same skills as those contributing to insight. For example, Schooler and Melcher (1995) conducted an individual difference study correlating individuals’ performance on eight standard insight problems with performance on a variety of cognitive measures, including vocabulary, Scholastic Aptitude Tests, embedded figures, need for cognition, anagrams, remote associates, categorization speed, mental rotation, logical problem solving, and most important, recognizing out-of-focus pictures. Of all these measures, recognizing out-of-focus pictures was the single best predictor of insight performance ($r = .45$). Of course, there is certainly much more to creative ability than simply being able to decipher degraded images; however, this finding illustrates the important manner in which creative achievement may depend on ability to see order where others perceive only randomness.

By focusing theories of creativity on blind selection, we run the risk of making the very same mistake as the individual who examines a degraded picture and concludes there’s nothing there. Certainly there may be random processes inherent in creativity, but a relatively brief perusal of just some of the cognitive processes that are likely to be associated with creativity suggests a variety of important components to creativity that are far from random, including sensitivity to hunches, spreading activation, problem characterization, knowledge organization, and pattern recognition, to mention but a few. And of course this should come as no surprise, because unlike genetic populations, in which in principle each member of the population is equally likely (due to the randomness of the process) to produce a useful mutation, when it comes to creativity, a minority of individuals are responsible for the majority of creations. One could, and some have, suggested that these individuals are simply randomly generating numerous ideas and thus producing more good ideas and more bad ideas than the average individual. However, in the final analysis this account simply does not wash. Although Shakespeare's worst plays may not have been as good as his best ones, they were still pretty darn good, and to a greater or lesser extent the same can be said for most creative individuals. They may lack restraint in releasing some of their lesser products, but they don't lack creative vision.

Notes

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Darwinian Creativity as a Conventional Religious Faith

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B. F. Skinner had a great theory of simple learning. Then Skinner tried to apply the theory beyond the range where it really worked well—for example, in the domains of complex problem solving and language acquisition—and both he and his theory lost credibility. Like many creative people, he became entrenched and then trapped by his own expertise (Sternberg & Lubart, 1995). Like many creative individuals, he tried to push a good idea too far. His faith outstripped his evidence.

Dean K. Simonton, one of the greatest and most creative minds in the study of creativity, has followed Campbell (1960) in attempting to apply an evolutionary perspective, but in the updated form of evolutionary psychology, to the study of creativity. I think evolutionary psychology has a central and important contribution to make, but its application to the creative process is nonoptimal, for five reasons.

Creativity Is Forward-Looking and Intentional; Evolution Is Not

First, "evolution by natural selection is not forward-looking and is not 'intentional'" (Buss, 1999, p. 8). Creativity typically is both forward-looking and intentional. Almost all theorists of creativity agree that some distinguishing characteristics of creative scientists are their purposeful selection of large and significant problems and their directing of efforts toward these problems. They are forward-looking and they are definitely intentional in their choices of topics and in their ways of coming up with ideas for these topics (see essays in Sternberg, 1999).

Scientific Theory Gives Way to Religious Faith

Second, Simonton has been explicit in a way in which many others only have been implicit—that this kind of theorizing represents not so much a scientific contribution as what I will call a religious faith. When Simonton says that "the overall creative process must be inherently Darwinian," he departs from scientific analysis and enters the domain of what seems to be more like a religious faith. If the creative process must be Darwinian, why seek commentaries? How can one argue with what must be? Moreover, when Simonton justifies his statement of faith by saying that his "point of departure for this extreme statement is the simple observation that the human brain is unbelievably complex," some readers may scarcely find the justification as compelling as does Simonton. The complexity of the brain Simonton proceeds to describe does not give rise to any necessity that creativity be Darwinian or, really, anything else.

Just-So Stories

Third, when Simonton admits that the "criticism is not without at least some justification" that "Darwinian theories sometimes seem as little more than compilations of 'just-so stories,'" he is admitting to a key problem both with his article and with many accounts of this ilk. These accounts, like those of Freud, seem to be able, after the fact, to encompass virtually any empirical findings at all.

The analogy to Freud is not casual. Some of Freud's followers have attempted to explain attempts to disagree with Freud in terms of Freud's theory. For example, someone who disagreed with Freud might be exhibiting a reaction formation or might be in denial. Darwinian theorists similarly can view non-Darwinian theories as representing less evolved ideas in an evolutionary chain of ideational development that has as its culmination the Darwinian theories.

The Evolution of Ideas Is Different From That of Organisms

Fourth, this point shows one of several ways in which Darwinian theories of creativity in particular, and perhaps of other constructs in general, differ from Darwinian theories of organisms.

For one thing, Darwinian evolution of organisms is open-ended. We do not know where the evolution of organisms will go, but we do know that the process is potentially an unending one with no ultimate "correct" or "most developed" form of organism. Darwinian theories, on the other hand, are presented as correct and as the most developed form of theories, encompassing other theories (as shown in Simonton's incorporation of other theories into his own framework). Presumably, we have reached the end of theory development, although the details of specific models under Darwinian theory may need still to be worked out. But this claim seems about as likely to be true as the claims made in recent books with such inane titles as *The End of History* and *The End of Science.* Fortunately, as developments have shown, neither history nor science has ended. The history of theory development in the field of creativity has not ended either.

Second, Darwinian claims about the evolution of organisms can be predictively tested via fossils as yet undiscovered. Evolutionary accounts such as that provided by Simonton in his target article are wholly postdictive.

Third, Darwinian claims applied to organisms do not have to be massaged to make them fit ideas. I believe it is no coincidence that Campbell (1960) used so many different and diverse words to describe the variation process. Simonton mentions *chance, random, aleatory, fortuitous, haphazard, unrestricted, unjustified, spontaneous,* and *blind.* Perhaps when many such words are used, it is because the construct is unclear, as is the construct now being called *blind variation.* At times, Simonton seems to be arguing it is truly blind, at other times, that there may be ways in which it is not truly blind.

Empirical Weakness of the Evolutionary Theory Applied to Creativity

Fifth, the evolutionary theory of creativity does not work and never has. It is just a weak theory that no doubt will have a long shelf life because it is nondisconfirmable and more a matter of religious faith rather than of science. Witness the incredible shelf life of Freud's theory. How weak the evolutionary theory of creativity is becomes clear when one reads the evidence supposedly supporting it. There is a section of Simonton's article called "Experimental Evidence." One reads it perhaps expecting to find experiments that directly support the Darwinian theory of creativity. The section contains not even a single such experiment. The next section is called "Psychometric Evidence," so one looks for psychometric evidence directly supporting the theory. There is none. The rest of the article is the same: sections whose content does not correspond to what a reader has the right, or at least the inclination, to expect. At best one can say that there are findings that are not wholly inconsistent with the evolutionary theory, but even this claim would be pushing things. And many other theories are at least as consistent with the findings presented.

The theory is especially weak in accounting for individual differences. How does the evolutionary theory of creativity account for the difference in creativity between Mozart and Salieri, or between Darwin and Lysenko, or between the greats and anyone else? The answer is that it doesn't, or at least, neither Simonton nor any other evolutionary theorist yet has given any comprehensible evolutionary account. Instead we are treated to statements such as that "any developmental factor that enhances the capacity of an individual to generate numerous and diverse variations should have a positive impact on the development of creative potential." Really, is there any theory of creativity that would take issue with this statement? Almost any plausible theory could account for these and similar claims. If the variation process is truly blind, as Simonton says, Mozart, Picasso, and other creative giants must have been damn lucky.

Simonton tries to create accounts of how these giants could be creative, but to the extent the accounts work, they go outside strict evolutionary theory, as indeed they have to. For example, high levels of native abilities, deliberate practice, motivation, unusual constellations of personality traits, and unusual environments really do not intersect well with the evolutionary theory of creativity. The weak integration Simonton attempts is forced and uncompelling.

Of course, the evolutionary theory of creativity can account for the evolutionary theory of creativity's being weak—creators have a relatively stable hit rate throughout their careers, and this contribution of Simonton's is not one of the hits. Unfortunately, the evolutionary theory of creativity also can account for the idea's being good—in exactly the same way. Here, one merely says the theory is one of the hits. Really, it is not clear that evolutionary theory directly accounts for any findings at all.

Conclusion

If one were to consider each statement in Simonton's article and count how many support or, even better, uniquely support the evolutionary theory of creativity, one would be left with little in one's hands, and arguably, one would be empty-handed. Indeed, Simonton himself has proposed other models that account for many of the findings he describes.

Maybe my views will be looked at by some as those of a Neanderthal in the creativity movement—as ideas that have reached or soon will reach an evolutionary dead end. After all, evolutionary theory applied to ideas, like Freudian theory, can account for its own opposition. But then, maybe I will get the last laugh when the evolutionary-model fad applied to creativity passes. Evolutionary psychology is best applied elsewhere. Correct ideas in psychology always have been notably scarce, although people who believe they have found such ideas have been anything but.

Notes

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An Evolutionary Model for Creativity: Does It Fit?

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Simonton (this issue) has presented an impressive discussion of the appropriateness of the Darwinian model of evolution for understanding the creative process. For many facets of creativity, the model may prove to be useful. However, for a key process, divergent thinking ability, the model does not fit. As Simonton stated, a key ability in creative production is the generation of a wide variety of ideas and associations. This ability to generate a variety of ideas, solutions to a problem, or associations to a word is commonly referred to as *divergent thinking* (Guilford, 1968). Simonton supports Campbell's (1960) thesis that the generation of associations in truly creative problem solving is random. Thus the blind variation model of genetic mutations in the process of evolution applies to divergent thinking. In blind variation, there is no foresight in the production of genetic mutations and recombinations. In divergent thinking, as they conceptualized it, the associations are random, with no guiding process to the search for associations. However, current theory and research suggest that there are guiding mechanisms involved in generating these associations. Guilford (1968) stated "divergent thinking is a matter of scanning one's stored information to find answers to satisfy a special search model" (p. 105). Divergent thinking does not imply random associations.

Sternberg (1998) presented cogent arguments that the generation of a variety of ideas and associations in creative problem solving is not blind variation but is sighted variation. Sternberg focused on cognitive processes in creative thinking. He reviewed the findings from the study of expert–novice differences in performance in many different domains. Experts try better paths to solutions than do novices (Holyoak, 1990). As in chess, great chess players generate better moves from the start than less creative chess players. Sternberg proposed three types of knowledge and processes that individuals use when generating ideas. Selective encoding is involved in deciding what information is relevant for a given purpose. Selective combination is involved in deciding how to combine elements of knowledge. Selective comparison is involved in relating new to old knowledge. Creative people consult these kinds of knowledge while generating solutions, although often without awareness of having used these knowledge bases. Sternberg concluded that repeated creativity in people is "anything but blind in the variation stage" (p. 172).

Affect and Divergent Thinking

Recent research has investigated the role of affective processes in creative production. Results are consistent with an affectively guided rather than random search process. A growing body of research studies have found relations between access to affect-laden thoughts and divergent thinking (Russ & Grossman-McKee, 1990) and facilitation effects for positive emotional states on divergent thinking (Isen, 1999; Isen, Daubman, & Nowicki, 1987). Theoretically, the involvement of emotion (affect-laden thoughts or affect states) broadens the search process for associations in creative problem solving by triggering associated memories and thoughts (Isen, 1999; Russ, 1993, 1999). One theoretical framework for understanding these findings is the associative network theory (Isen et al., 1987). Bower's (1981) associative network theory proposed that each emotion is a memory unit; each emotion has a special node or unit in memory. The activation of the emotion unit aids the retrieval of events associated with it. It primes emotional thematic imagery for use in free association, fantasies, and perceptual categorization. Rholes, Riskind, and Lane (1987) expanded on Bower's theory and discussed mood-related cognitions. Affect states activate a set of relevant cognitions that are mood related. A cognitive priming process occurs.

A more recent theoretical model is Getz and Lubart's (1999) emotional resonance model of creativity, in which emotions contribute to the access and association of cognitively remote concepts in memory. In this model, emotions become attached to concepts or images. These are labeled *endocepts*. Associations are emotion based and may resonate with each other when triggered. Endocepts attached to concepts resonate with each other and link concepts in memory.

Russ (1993) speculated that individuals who are open to affect states and affect-laden cognition benefit in carrying out creative tasks in two ways. First, they have access to more cues that activate other nodes in the search process. More associations occur. Second, more emotionally salient material would get coded and stored when individuals were in an emotional state. For individuals open to affect, more would "get in," thus providing the individual with a richer network of affect-relevant associations. This storing of affective content would be especially important for artistic creativity, where one is often dealing with affect and the transformation of affect content into universal symbols. There is evidence that creative individuals are more sensitive and open to experience than noncreative people (McCrae & Costa, 1987; Richards, 1990).

The question relevant to this discussion is whether affective involvement aids a random search process or a guided search process. An affect-guided search process seems to follow from these theoretical models. The triggering of networks of mood-relevant associations would access sets of associations especially relevant to the problem being worked on. This would be especially true of artistic creativity. For example, a painter attempting to capture the pain of loneliness would search a set of mood-relevant images and memories. Affect would partially determine which set of associations was triggered.

One example of this kind of affect-guided association is the free association process used in psychoanalytic and psychodynamic treatments. The therapist encourages the patient to free-associate and communicate his or her thoughts. The assumption is that the free associations are not random but are guided by emotions and unconscious processes. The set of associations that occur have meaning, often symbolic meaning, that are guided by issues being worked on in the treatment. The free-association method is meant to bring out a determinate order of the unconscious (Laplanche & Pontalis, 1973).

Affect could guide the search process in another way. As ideas, associations, or images are generated, some are more salient than others. Affect would guide the selection process. Consistent with Damasio's (1994) hypotheses of the somatic marker, there is a constant interaction between cognition and emotion in decision making. Affect would guide the generation of associations and the continual evaluation of the associations that emerge.

In Damasio's (1994) somatic-marker hypothesis, cognitive images become marked with physiological responses that reflect emotions. Damasio applied his model to decision making, but it is also applicable to divergent thinking. As associations occur, they are highlighted (or made salient) by positive and negative emotional responses. These emotional and physiological responses are rapid and often out-of-awareness or unconscious processes (Damasio, 1994; Simon, 1998). Damasio quoted the creative mathematician Henri Poincaré, who describes a nonrandom process of associations. Poincaré (Ghiselin, 1952) stated that to create involves making "useful" combinations of ideas. One sifts through a minority of useful possibilities. It is as if a preselection process had already occurred. Only potentially useful associations are considered. This may be an oversimplification of the process; however, it is consistent with the concept of a guided association process.

A third way in which affect can guide the generation of variations is in the transformation of personal experiences, memories, and images into universal images that occurs in truly great art. Often, artists incorporate early conflicts and traumas into their art (Niederland, 1976). Understanding exactly how these complex transformations occur is a task for future research. However, when affect is so intertwined with cognitive processes in a creative act, the picture becomes more complicated than one of random variation.

In conclusion, there is theory and research in the creativity area that would suggest that the search process involved in divergent thinking and the generation of variations is not random but sighted, as Sternberg (1998) stated, and guided by affect. Although some creative productions would be a result of random search processes, many would not be. Ultimately, the question of whether the generation of associations is random is an empirical one. Hopefully, future research will answer this question definitively. At the moment, there appears to be method behind the search.

Note

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