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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