Creative Thought as Blind Variation and Selective Retention: Why Creativity is Inversely Related to Sightedness

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Campbell (1960) proposed the theory that creativity required blind variation and selective retention (BVSR). More than a half century has transpired without any resolution of the controversy over the theory's validity. This inability to reach consensus may reflect a fundamental failure on both sides to define the critical terms of the debate, namely, creativity and blindness. Hence, to help resolve the issue, the ideas making up a variant set are first described via three parameters: (a) the idea's initial probability of generation, (b) its final utility, and (c) any prior knowledge of its utility value. These three subjective parameters are then used to derive a *creativity index* applicable to each idea in the set. The same parameters are also deployed to produce a *sightedness metric* that describes the sightedness of the variant set as well as each idea in that set. It is then logically demonstrated, first, that an idea's creativity is inversely related to its sightedness, and, second, that an idea's creativity is inversely related to the sightedness of the variant set that contains that idea. Furthermore, the same general conclusions hold when the third parameter is omitted from the two definitions or when the two definitions are not functions of identical parameters (e.g., novelty in one but originality in the other). Because blindness is just the inverse of sightedness, it automatically follows that creativity has an essential positive connection with blind variation. The article closes with a discussion of BVSR implications regarding the joint distribution of creativity and sightedness.

Keywords: creativity, sightedness, blindness, BVSR

Although creativity has often been seen to be a neglected topic in psychology (Guilford, 1950; Sternberg & Lubart, 1996), the subject has experienced an exceptional influx of interest over the past dozen years or so (for recent reviews, see Hennessey & Amabile, 2010; Runco, 2004). Indeed, creativity research now attracts psychological research from multiple subdisciplines, including the cognitive neurosciences, differential and personality, life span development, and social. That increased attention is not without its costs. Alternative theories, measures, and methods have proliferated almost without bounds, introducing numerous controversies. One of these persistent debates concerns whether creativity is generic or domain

specific (Simonton, 2007b; Sternberg, 2005). Is there a single "creative process" (or set of processes) that operates in all domains, whether artistic, scientific, or technological? Or is creativity so contingent on domain-specific expertise that artists, scientists, or inventors all create in very different ways? Should domain-specificity be the norm, then psychologies of creativity would have to be as numerous as domains of creativity, a possibility that must seriously complicate research—and might even render psychology irrelevant as an explanatory perspective. Relative to any creativity researcher, poets would know appreciably more about how to create poetry, and physicists know more about how to be creative in physics.

A potential solution to this problem might have been provided by Donald T. Campbell (1960) over a half century ago (Simonton, 2011b). In particular, Campbell argued that all creativity depends on the two-step procedure of blind variation and selective retention, or "BVSR." Of these two steps, the first is the most

critical and the least obvious. In simple terms, to be creative requires that the person go beyond the information given, to take intellectual risks, to hazard guesses that may turn out to be no more than shots in the dark—in short, to dare to be wrong. Because Campbell believed that BVSR applied not just to creativity but also to "other knowledge processes," he viewed this two-step procedure as truly general rather than domain specific.

Unfortunately, Campbell's argument was neither empirical nor logical (Martindale, 2009). Rather than present data to support his view, or provide a formal demonstration of its validity, he devoted his article mostly to quoting compatible philosophical positions (viz., Bain, 1855/1977; Mach, 1896; Poincaré, 1921; Souriau, 1881; but not James, 1880). Nor did Campbell improve matters in subsequent publications. In his later years he "waxed philosophical" by transforming BVSR into his broader evolutionary epistemology (Campbell, 1974a), a theoretical development that he explicitly connected with the "conjectures and refutations" in Karl Popper's (1963) own philosophy of science (see also Campbell, 1974b). Perhaps not surprisingly, then, Campbell's BVSR model seems to have had the greatest impact on philosophical thinking (e.g., Bradie, 1995; Briskman, 1980/2009; Heyes & Hull, 2001; Kantorovich, 1993; Nickles, 2003; Stein & Lipton, 1989; Wuketits, 2001). Of special epistemological interest is the intimate connection between BVSR and the "Meno problem" (from Plato's classic dialogue) of how it is even possible to acquire knowledge without having some a priori knowledge (Nickles, 2003). BVSR does not presuppose that we can knowingly generate new knowledge but only that we have selection criteria for judging which of several potential knowledge offerings is most likely to count as knowledge. As will be seen shortly, these criteria are intimately connected with the very definition of creativity.

Although some psychologists have attempted to develop and extend Campbell's (1960) ideas both theoretically and empirically (Cziko, 1998; Damian & Simonton, 2011; Martindale, 1990; Perkins, 1998; Simonton, 2007a, 2009, 2010, 2012b; Staw, 1990), the BVSR theory of creativity remains contentious (Simonton, 2011b). The opponents may even outnumber proponents. Key critics include the psychologists

Gabora (2010, 2011), Sternberg (1998), and Weisberg (2004), the computer scientist Dasgupta (2011), and the philosophers Thagard (1988) and Kronfeldner (2010). In any event, discussion does not seem any closer to consensus than it was 50 years ago (Simonton, 2011c). The BVSR theory of creativity has been neither conclusively rejected nor resoundingly confirmed.

This failure to reach agreement may have several causes. For example, BVSR has been falsely equated with assertions that (a) the theory depends on an analogy with Darwin's theory of evolution, (b) ideas must be generated randomly, (c) volition plays no role in the creative process, and (d) domain-specific expertise is irrelevant (Simonton, 2011b, 2012c). Although none of these claims are true, they are often repeated (Simonton, 2011b, 2011c). Here I would like to suggest an even more critical reason for not attaining consensus: All parties participating in the debate have failed to define the key terms precisely. Specifically, neither proponents nor opponents have converged on rigorous answers to the following two questions. First, what counts as a creative idea? Second, what constitutes a blind variation? I will argue here that once these two concepts are both given precise definitions, the controversy simply vanishes. Creativity and blindness have a necessary and positive connection that cannot be denied without redefining either term in a vague or arbitrary manner.

To make my case, I start by defining these two core terms, and then work out the implications of those definitions. I then consider two possible objections to the derivations, showing the main derivations are quite robust. I close with a general discussion regarding broader implications. Before entering this extended analysis, however, a caveat is in order.

The arguments that follow will depend on logic and mathematics somewhat more formal than is the norm not just in creativity research, but also in psychology at large. Psychologists tend to prefer purely verbal definitions and derivations, often believing that the conceptual precision seen in the mathematical and computer sciences is superfluous if not pernicious. Perhaps so. Yet creativity researchers have been applying these linguistic methods for decades without being able to resolve some key controversies, including what counts as a creative idea

(Simonton, 2012c, in press-c). Therefore, it may be worth at least a try to adopt the precision of mathematics to see where it takes us. If the debates still continue unabated even after careful consideration of this article, then perhaps there just may be psychological issues that are immune to scientific resolution.

Definitions

Let us suppose that a person can potentially generate k ideas, where $k \geq 1$. This ideational production may have resulted, for example, from a given problem that obliges the individual to venture one or more possible solutions. Let each of these k ideas be designated by x_1, x_2, x_3, . . . x_i . . . x_k and the whole variant set by X (cf. Simonton, 2011a). These k ideas may then represent the alternative potential solutions to the provided problem.[1] As an illustration, Maier's (1931, 1940) well-known "two-strings" problem required that research participants tie two cords together that were hung too far apart from the laboratory ceiling. Given several objects that they were informed could be used to carry out the task, participants generated up to seven possible solutions, so that conceivably $k = 7$ (albeit only four of these actually worked). Whatever the specific representation might be, each idea can be described by the following three parameters (cf. Simonton, 2011a):

1. The initial subjective *probability* that idea x_i will be generated by the person can be indicated by p_i, where $0 \leq p_i \leq 1$ and Σ $p_i \leq 1$. The latter inequality allows for the possibility that all of the potential solutions to a problem might have likelihoods so low that the probabilities will not even sum to unity, a situation that arises when all rival solutions have very weak "response strengths." In contrast, because the probabilities apply to alternative responses, their sum cannot exceed unity. Lastly, if $p_i = 0$, then the idea x_i is not immediately accessible, but can presumably be evoked after an incubation period requiring a suitable priming stimulus or stimuli (Hélie & Ron, 2010; Seifert, Meyer, Davidson, Patalano, & Yaniv, 1995). If otherwise, then k should really be reduced to that number of ideas that

can be potentially generated within a reasonable period of time. The trivial case would occur when $k = 0$ because the individual cannot conjure up a single relevant idea no matter how long he or she contemplates the problem.

2. The subjective probability that idea x_i will eventually prove useful (and hence be selected and retained) is given by the *utility*, u_i, where $0 \leq u_i \leq 1$ and $0 \leq \Sigma$ $u_i \leq k$ (i.e., from none of the potential solutions work to all of them work just fine). Although an idea's utility is technically a continuous variable, in many cases it reduces to a dichotomous 0–1 variable. For example, in Maier's (1931, 1940) two-strings problem, either a solution manages to tie the two strings together or it fails completely to do so. There are no intermediate solutions. To simplify the analyses that follow, I will always assume that $u_1 = 1$ and that $u_i = 0$ for all $i \neq 1$. In brief, the creator's task is to discover the single solution that works out of the set of k hypothesized solutions.[2] For instance, when James Watson endeavored to find the DNA code given the four bases, $k = 4$ (i.e., there were four possible arrangements), but only one set of pairings (viz., adenine-thymine and guanine-cytocine) yielded a workable chemical structure (Watson, 1968).

3. The person's subjective prior *knowledge* of u_i is given by v_i, where $0 \leq v_i \leq 1$ and Σ $v_i \leq k$. When $v_i = 0$, the individual is ignorant of whether or not the idea will be useful without first conducting a generation and test of that idea, but when $v_i = 1$ the individual already knows the value of u_i in advance, and perfectly. In the latter

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[1] A different representation of the phenomenon is to view creativity and discovery as entailing combinatorial processes (Simonton, 2010). The parameters then apply to the k combinations that emerge from these processes. Of course, to the extent that creativity, discovery, and invention depend on generating ideational or behavioral combinations (Thagard, 2012), these two perspectives are equivalent (see also Poincaré, 1921).

[2] This simplification permits us to avoid the need to normalize the parameters according to the proportion of ideas in the set with positive utilities. Yet the conclusions to be drawn later remain unchanged except for their becoming more complicated.

case, a generation-and-test, trial-and-error, or variation-and-selection procedure is unnecessary to determine u_i. In genuine algorithmic problem solving $v_i = 1$, whereas in heuristic problem solving $v_i \ll 1$ (cf. Amabile, 1996; Simonton, 2011b). If the value of v_i lies somewhere between 0 and 1, we may call the idea a "hunch" based on some tacit knowledge yet to be articulated (the exact value indicating variable "feeling of knowing" states; Bowers, Regehr, Balthazard, & Parker, 1990; cf. Platt & Baker, 1931). Then to discover that the idea proves useful can still provoke some surprise. We must also allow for the possibility that all of the utilities might be perfectly known, whether useful or useless, in which case $\Sigma v_i = k$. When this occurs, BVSR is rendered irrelevant. BVSR is only germane for distinguishing high utility from low utility variants when the utilities are initially unknown. When mathematicians use the quadratic formula to solve a second-order differential equation, the resulting roots are known to work with certainty, obviating any need for trial and error. Presumably, too, any idea with the parameter values $v_i = 1$ and $u_i = 0$ will not even be included in set X, for then it would be anticipated that $p_i = 0$, and thus, x_i will not even be subjected to BVSR (cf. "preselection" in Simonton, 2011b). For instance, theoretical physicists automatically ignore any hypothesis that would require the violation of one or more fundamental natural laws, such as the conservation of energy.

Before continuing, I must emphasize that the three parameters are all subjective rather than objective. For the current treatment of the creativity-BVSR relation, the focus is on the individual trying to solve a problem to his or her own satisfaction. To require that these parameters be defined objectively or consensually would introduce complications that are not needed for the question addressed here (Simonton, 2010, in press-c). After all, Campbell's (1960) original formulation of BVSR concentrated on "thought trials" occurring within a given person's head (Simonton, 2011b). In this respect, the creator is like Dennett's (1995)

"Popperian creature" who engages in testing conjectures against an internal representation of the external world—an internalization that "permits our hypotheses to die in our stead" (p. 375). Nonetheless, BVSR may also operate in Dennett's "Skinnerian creature" where the thought trials become actions that are tested directly against the external world because the internal representation is unavailable or imprecise. Indeed, often BVSR is used to test alternative internal representations against external reality. In either case, the individual alone decides the parameter values.[3]

Given the forgoing specifications, we can now define the creativity index and the sightedness metric.

Creativity Index

Despite the fact that Campbell's (1960) article specifically dealt with "creative thought," he never defined what creativity entails. Perhaps this omission was deliberate rather than neglectful, because he thereby avoided a knotty problem. In fact, creativity researchers have yet to reach agreement of what counts as a creative idea (Plucker, Beghetto, & Dow, 2004). To be sure, most psychologists have agreed on some variety of a two-criterion definition: A creative idea must be both (a) original or novel, and (b) useful, adaptive, or valuable (Simonton & Damian, in press). This two-part conception has even been styled the "standard definition" (Runco & Jaeger, 2012). Even so, a three-criterion definition may actually be necessary to capture the full complexity of what creativity really means (Simonton, 2012c). For example, Boden (2004) required that a creative idea be novel, valuable, and surprising. Similarly, the U.S. Patent Office demands that an invention be novel, useful, and nonobvious to receive patent protection (http://www.uspto.gov/inventors/patents.jsp; see also Sawyer, 2008). Also comparable is Amabile's (1996) statement that "a product or response will be judged as cre-

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[3] Although the examples of creativity used in this article emphasize real scientific discovery episodes and problem-solving experiments, it should be clear that the subjective definition of utility permits a very straightforward application to artistic creativity. The usefulness of a musical, literary, or graphic idea is contingent on the artist's personal appraisal of whether that idea satisfies an applicable aesthetic criterion, such as beauty or meaningfulness.

ative to the extent that" it is (a) novel, (b) "appropriate, useful, correct or valuable response to the task at hand," and (c) "the task is heuristic rather than algorithmic" (p. 35). The last contrast is also echoed in Perkins's (2000) distinction between *reasonable* problems that "can be reasoned out step by step to home in on the solutions" and *unreasonable* problems that "do not lend themselves to step-by-step thinking. One has to sneak up on them" (p. 22). Only unreasonable problems imply that the creator enjoys an "aha!" or eureka experience that certifies the surprise. Such problems often require classic Gestalt restructuring before a solution obtains (Köhler, 1925; Wertheimer, 1945/1982).

Once creativity is conceived according to a three-criterion definition, then it becomes apparent that the creativity of any idea in variant set *X* may be defined in terms of the three parameters that describe any given idea in the set of *k* variants (Simonton, 2012c). In particular, (a) an idea's *originality* is given by $(1 - p_i)$, that is, highly original ideas have low initial probabilities, (b) its eventual usefulness or utility is given by u_i, just as before, and (c) its *surprisingness*, or nonobviousness, is defined by $(1 - v_i)$, which gives the degree of ignorance prior to generating and testing the idea to assess its utility.

What is left to determine is how $(1 - p_i)$, u_i, and $(1 - v_i)$ are integrated to form a combined index of an idea's creativity. Given that all three criteria range from 0 to 1, I can propose the following creativity index:

$$c_i = (1 - p_i)u_i(1 - v_i),$$

where $0 \leq c_i \leq 1$ (cf. Simonton, 2012c, who gives a preliminary version). In other words, the creativity of a given idea is the joint product of its subjective originality, utility, and surprisingness. If any of these values equal zero—that is, the idea is everyday, worthless, or obvious—then creativity equals zero. To illustrate, a reinvented wheel will not be creative because $(1 - p_i) = 0$, a bank safe made out of ordinary soap bubbles will not be creative because $u_i = 0$, and an invention that is a straightforward adaptation of a previously patented invention will not be creative because $(1 - v_i) = 0$ (cf. Kirton, 1976). In contrast, the creativity index only maximizes as all three factors approach unity. Einstein's special theory of relativity was highly creative because it was highly original, highly useful, and highly surprising.

Sightedness Metric

Campbell (1960) not only failed to define creativity, but he also neglected to provide a sufficiently precise definition of blind variation (Simonton, 2011b). He merely began by saying that "an essential connotation of blind is that the variations emitted be independent of the environmental conditions of the occasion of their occurrence" (p. 381), then adding that "a second important connotation is that the occurrence of trials individually be uncorrelated with the solution, in that specific correct trials are no more likely to occur at anyone point in a series of trials than another, nor than specific incorrect trials" (p. 381). Significantly, his definition of variant blindness depended on "connotations" rather than "denotations." I believe that the failure to offer an explicit and precise "denotative" definition stimulated numerous misunderstandings that undermined the persuasiveness of an otherwise powerful theory (Simonton, 2011b, 2011c). These misconceptions led researchers to overlook the essential connection between creativity and variation blindness (e.g., Sternberg, 1998; Thagard, 1988). Unhappily, later advocates of the BVSR theory of creativity spent the next 50 years working with the same inadequate definition.

Ironically, the solution to this problem was inadvertently offered by a strong BVSR critic, namely, Kronfeldner (2010), who argued that a "blind variation" should be conceived along the same lines that the philosopher Sober (1992) defined an "undirected mutation" in evolutionary biology. As Sober put it, "Let u be the probability of mutating from A to a and v be the probability of mutating from a to A. Mutation is directed if (i) u > v and (ii) u > v *because* w(a)>w(A), where w(X) is the fitness of X" (p. 39; italics added). If the former two stipulations do not hold, then the mutation is undirected. Kronfeldner related Sober's specification to Toulmin's (1972) concept of "decoupling," meaning that "the factors responsible for the selective perpetuation of variants are entirely unrelated to those responsible for the original generation of those same variants" (p. 337). Kronfeldner went on to insist that "Given this

definition, directedness is a matter of degree, whereas undirectedness is simply the absence or negation of any directedness and thus (logically) not a matter of degree" (p. 196). By extension, ideas can be either blind or not blind, but do not admit of degree.

This latter inference is fallacious for two reasons. First, real blindness admits of degrees as well: Having unaided vision of 20/200 makes one *legally* blind, but a person with 20/150 vision is *less* blind and one with 20/250 vision is *more* blind (Simonton, 2012a). Second, Kronfeldner's (2010) inference depends on imposing an analogy between Darwinian evolution and BVSR, an analogy that is not required for BVSR to be valid (Simonton, 2012a). In fact, as Campbell (1960) himself pointed out, a BVSR prototype was first advanced by the philosopher Alexander Bain (1855/1977) four years before Darwin published his *Origin of Species*. Thus, BVSR is historically prior to evolutionary theory (and certainly prior to the concept of mutation).[4] Furthermore, with one exception, none of the early advocates of a pre-Campbellian BVSR relied on an evolutionary analogy. This group included Paul Souriau (1881), Ernst Mach (1896), and Henri Poincaré (1921). The lone exception was William James (1880), whose version was directly influenced by Darwin. Perhaps for this reason Campbell (1960) did not cite James at all, wanting to minimize any perceived link between BVSR and Darwin (cf. Campbell, 1974a, where James was mentioned but dismissed as off the mark).

In any case, once we accept that BVSR stands or falls without leaning on Darwinian theory, then we can allow that blindness admits of degree. There can indeed be variable amounts of "directedness" or "coupling." Even more importantly, a close look at Sober's (1992) definition reveals a way to provide a metric for assessing the magnitude of blindness. To see this, I must first translate his definition into the terms used here. Notice that his conception implies three variant parameters: (a) the probabilities of a and A, (b) the fitness values of a and A, and (c) the degree to which the fitness values imply the probabilities because they are already previously "known" by the organism (whatever that may mean). These three parameters can then be expressed as p_a and p_A, u_a and u_A, and v_a and v_A, respectively. Here "fitness" simply becomes usefulness. Although Sober's

conception deals with only two variants, it is easy to generalize to any number of k variants by introducing the appropriate numerical subscripts.

The next step is to define a metric that describes the "sightedness" of variant set X (cf. Sternberg, 1998). This measure is here defined as

$$S = 1/k \sum p_i u_i v_i,$$

that is, the average of the joint products of the initial probabilities, final utilities, and prior knowledge values for all k variations. It necessarily follows from the definitions of the three parameters that $0 \leq S \leq 1$, where 0 indicates total blindness and 1 indicates total sightedness. Clearly, because we are not constrained by any fallacious evolutionary analogy to view blindness as a dichotomous variable, we can justifiably define blindness as $B = 1 - S$ (cf. Simonton, 2012b). Under this formulation, $B = 1$ and $S = 1$ represent the two endpoints of a blind-sighted continuum.[5] It also should be apparent that $S = 0$ whenever $v_i = 0$ for all i, which also specifies the necessary and sufficient condition for undirected mutation in Sober's (1992) definition. Because such mutations do not have advance knowledge of what their fitness values will be, it follows that $v_a = v_A = 0$. Any correspondence between the probabilities and the utilities becomes right away irrelevant, no matter how perfect.

Given that the set sightedness metric is defined as the average of the separate threefold product terms, each of those single terms can be taken as a measure of a particular idea's sightedness. That is, it is sensible to specify that $s_i = p_i u_i v_i$, which also can range from 0 to 1. Hence, $s_i = 1$ indicates that the variant x_i is totally

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[4] Interestingly, while Darwin was working on the *Origin*, a friend advised him to read Bain's work. Although he actually purchased a copy, and shelved the volume in his library, he never managed to read it (Simonton, 2011b). If he had done so, we might be calling Darwin's own theory "Bainian." In any event, rather than view BVSR as "Darwinian," it is more conceptually precise to view both BVSR and Darwin's evolutionary theory as special cases of universal selection theory (Cziko, 2001).

[5] Simonton (2011a) introduced similar ideas, but proposed an incorrect metric (viz. Tucker's phi coefficient of congruence used to assess the similarity of two sets of factor loadings) that was applied solely to what here would be styled **p** and **v** vectors, excluding the **u** vector. The current metric is far superior, besides not being wrong.

sighted and $s_i = 0$ indicates that the variant is totally blind. Correspondingly, the blindness of a single "thought trial" is defined as $b_i = 1 - s_i$. An example would be a serendipitous discovery in which a person discovers something useful in a completely unanticipated manner (cf. Díaz de Chumaceiro, 1995; Kantorovich & Ne'eman, 1989). In such instances, $v_i = 0$ and hence $b_i = 1$.

Implications

Using the above definitions, I will draw two groups of logical inferences regarding variant sets. The first inference concerns the relation between c_i and s_i (the sightedness of the single idea x_i) and the second the relation between c_i and S (the sightedness of set X that contains idea x_i).

An Idea's Creativity and Its Sightedness

One central implication should be apparent at once: Highly creative ideas cannot be highly sighted. This antithetical relation follows immediately from the definitions of c_i and s_i.

In the former case, $c_i \rightarrow 1$ as $p_i \rightarrow 0$, $u_i \rightarrow 1$, and $v_i \rightarrow 0$, where "$\rightarrow$" is taken to mean "approaches" (as employed in the mathematical concept of limits). Creativity maximizes when originality, utility, and surprise all maximize.

In the latter case, $s_i \rightarrow 1$ as $p_i \rightarrow 1$, $u_i \rightarrow 1$, and $v_i \rightarrow 1$. Sightedness maximizes when originality minimizes, utility maximizes, and surprise minimizes. If the utility is fixed at some nonzero value, say unity, then c_i and s_i must be negatively correlated. Although equally useful, the highly creative idea will have a low probability and high surprisingness, whereas the highly sighted idea will have a high probability and a high obviousness.

Indeed, any idea x_i in which $p_i = 1$, $u_i = 1$, and $v_i = 1$ so that $s_i = 1$ must be considered routine, reproductive, or algorithmic in nature. For example, most of the solutions to Maier's (1931) two-strings problem were of this type—such as tying one string to an extension cord and then bringing it over to the other string (the adjective "extension" provides a telling clue). In contrast, Maier identified the pliers-as-pendulum solution as productive or creative because although it is equally useful, it had a low probability and low obviousness. As Maier (1940) expressed it, making a pendulum using pliers contained "an element of surprise and a change

in meaning since the tool changes to a weight and the string, which was too short, suddenly becomes too long and must be shortened" (p. 52). Even participants given prior experience working with standard pendulums did not display a higher probability of devising this solution. Moreover, participants usually needed hints from the experimenter before they solved the problem in this specific fashion. These prompts functioned in a manner similar to the extraneous stimuli that often prime associations (via spreading activation) to yield insights (Simonton, 2011b), as illustrated in the famous bathtub eureka experience of Archimedes (Boden, 2004). Seeing the water overflow as Archimedes stepped in made him realize that any object will displace an amount of water equal to the volume of the object. All of his prior mathematical and mechanical prowess did not and could not lead him to this insight. He was dealing with an unreasonable problem.

An Idea's Creativity and the Sightedness of the Variant Set

Because S is the average of all k s_i's, it is obvious that the inverse relation between c_i and s_i also extends to c_i and S. Even so, the connection is more complex. Let us first consider what happens as $S \rightarrow 1$, that is, as the variant set X becomes increasingly sighted. This requires that $p_1 \rightarrow 1$ and $v_1 \rightarrow 1$, making x_1 more sighted as well—but also less creative. Meanwhile, for any $i \neq 1$, it must follow that $p_i \rightarrow 0$ because of the constraint $\Sigma p_i \leq 1$. Hypothetically, when $S = 1$, then $p_1 = v_1 = 1$, and $p_i = 0$ for any $i \neq 1$. In words, if there is only one useful idea in the set X, and the set is perfectly sighted, then the individual will only generate the single useful idea, so that, in effect, $k = 1$. Because $v_1 = 1$, there is no need whatsoever to engage in BVSR, but, that truth admitted, $c_1 = 0$.

Now consider what happens when a set's sightedness is decreased rather than increased, so that $S \rightarrow 0$. Does that necessitate that all of the ideas in that set decline in creativity as well? Quite the contrary! Again, to keep the analysis simple, suppose that $u_1 = 1$ but that $u_i = 0$ for all $i \neq 1$. Then sightedness goes to zero as $p_1 \rightarrow 0$ and $v_1 \rightarrow 0$. Yet these are the exact changes required to make $c_1 \rightarrow 1$. Accordingly, if $p_1 = 0$ and $v_1 = 0$, then $S = 0$, exactly. Put differently, set X can contain a maximally creative

idea even when $B = 1$. Mutatis mutandis, the closer the set is to being blind, the more creative will be the single useful idea that emerges from BVSR!

In conclusion, the heart of BVSR theory is that creativity requires generating and testing ideas with unknown or not fully known utilities. That requirement alone is what renders the variation procedure "blind." The variation-selection process is then needed to gauge the utilities. If the utilities are already known in advance, then ideas need not be blind, but then none of the ideas can be creative either. Any "testing" of highly sighted ideas then constitutes mere "quality control," "doing the math," or "fact checking." When Campbell (1960) explicitly linked BVSR with "knowledge processes," he meant that the procedure was needed to learn something new, not to verify what was already known. BVSR moves unjustified conjectures from the ignorance column to the knowledge column. At the end of BVSR, $v_i = 1$ for all x_i.

Objections

Whether we scrutinize the relation between c_i and s_i or that between c_i and S, creativity and sightedness are inversely related. It is decidedly impossible for a highly creative idea to emerge from a highly sighted variant set, and the creativity of any useful idea tends to increase as the variant becomes less sighted. In addition, I have not exhausted the ways that creativity and sightedness can be inversely related. As an example, consider the consequences of increasing k without correspondingly increasing the number of useful ideas in the variant set. It is easy to prove that as the proportion of useful ideas declines, the set's sightedness will decrease as well, whereas the creativity of any useful idea in the set will concomitantly increase because its relative probability must perforce decrease. So, again, an inverse relation obtains.[6]

Is it even possible to conceive a scenario where creativity and sightedness correlate positively? It would not seem so. The crux of the matter is that our reasonable definitions of the two constructs introduce an inherent conflict. Only the ultimate utilities are positively correlated with both creativity and sightedness, whereas the initial probabilities and prior knowledge values have utterly divergent correlations with creativity and sightedness. Admit-

tedly, a BVSR critic might try to reject the definitions that lead to these uncomfortable results. Yet even this escape may not work. Let me consider two possibilities: (a) removing the parameter v_i from both creativity and sightedness definitions, and (b) defining creativity and sightedness using different but still plausible parameters.

Two-Parameter Definitions of Creativity and Sightedness

Because v_i plays such a critical role in the above definitions of creativity and blindness, perhaps this parameter was just snuck in to bias the logical derivations in favor of BVSR. Hence, let us consider what happens if v_i is removed from the definitions of c_i, S, and s_i. We thereby obtain $c_i = (1 - p_i)u_i$, $S = 1/k \sum p_i u_i$, and $s_i = p_i u_i$ (cf. Simonton, 2012a). In short, ideas can be creative even when they are obvious extensions of previous knowledge, and variant sets or the ideas contained within those sets can be perfectly sighted even when the individual actually does not know the utilities in advance of their generation and testing. There are two problems with this maneuver.

First, it must be fundamentally unsettling to call an idea "sighted" even when the individual may be entirely ignorant of its utility. For example, the two-parameter definition means that a purely "lucky guess" counts as sighted: A person who had a response bias to call heads rather than tails in multiple coin flips, when the coin just so happened to be loaded strongly toward heads (without her knowledge), would then be sighted rather than blind—when the latter attribution would hold if v_i were included. This point tells us why we need a three-criterion definition in the first place. If the definitions of S and s_i omit v_i, then the formulas can only represent necessary but not sufficient conditions

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[6] One might object that having to engage in more trial-and-error operations should render the resulting useful idea more lucky than creative. Yet here is where Campbell's (1960, p. 390) expression "creative thought as in other knowledge processes" becomes most insightful. Which contributes more to knowledge, finding the most useful idea out of 100 possibilities or the most useful idea out of 10? That Edison tested hundreds of potential incandescent bulb filaments rather than just a dozen gives us more confidence that the one he found had the highest possible utility. To maximize enhances expertise more than to satisfice.

for set and variant sightedness. The same limitation holds if v_i is left out of the definition of the idea's creativity. The truncated definition then gives necessary but not sufficient conditions for an idea to be creative.

Second, this revision of the definitions does not even destroy the inverse relation, as can be immediately deduced from the reduced formulae. Because $(1 - p_i)$ must still have a perfect negative association with p_i, for any given value of u_i, c_i must be negatively correlated with both S and s_i. The only qualification imposed on our previous deductions is that if $S = 0$, any idea with a positive utility must have a zero initial probability. The knowledge value $v_i = 0$ is then missing to guarantee blindness even when $p_i >$ 0. Hence, BVSR opponents who still want to establish a positive relation between creativity and sightedness must somehow demonstrate that originality is positively correlated with an idea's probability! The most original ideas are the most probable ideas? Such a demonstration—whether logical or empirical—seems most unlikely.

Defining Creativity and Sightedness With Different Parameters

The argument pursued so far might still be accused of legerdemain. Both creativity and sightedness have been defined in such a way that an inverse relation is guaranteed. Although the parameter u_i contributes to both creativity and sightedness in the same direction, p_i and v_i contribute in opposite directions because c_i decreases as p_i and v_i increase whereas s_i (and S) increase as p_i and v_i increase. In the previous section, it was already shown that the same basic results obtain if v_i is left out of the definitions, so that cannot be the source of any logical trickery. Moreover, it should be obvious that u_i cannot be held to blame. Useless ideas must be neither creative nor sighted. Consequently, any BVSR opponent must focus on p_i, the initial subjective probability of generating idea x_i. In the above formal analysis, p_i was a factor in the definition of sightedness while $(1 - p_i)$, as a gauge of originality, was a factor in the definition of an idea's creativity.

This latter factor might be open to attack. After all, many creativity definitions, whether they use two or three criteria, specify the first criterion as novelty rather than originality

(Plucker et al., 2004; Runco & Jaeger, 2012; cf. Simonton & Damian, in press). Can it then be argued that an inverse relation between sightedness and creativity is merely the specious result of replacing "new" with "original"? Undoubtedly, if novelty and originality are not equivalent, then sightedness would bear a different relation with creativity. The response to this criticism is twofold.

First, it can be argued that the novelty criterion actually represents a conceptual conflation of originality and surprise. The three-criterion definition used here thus attains more precision than a two-criterion definition using novelty and utility because originality and surprise are thus allowed to vary independently to the extent necessary to acknowledge their separate impact on creativity. A concrete case is the Pelton water wheel that was actually conceived by two independent inventors (Constant, 1978). Although the two inventions were perfectly identical, and thus, equally original and useful, one inventor adapted the wheel from a previous invention whereas the other inventor unknowingly came up with the same idea after a serendipitous event that rendered the result highly surprising (Simonton, 2012c). Only the latter sought patent protection—and got sole credit for an equivalent invention.

Second, and regardless of whether one accepts the first response, any attempt to replace originality with novelty does not extirpate the inverse relation between creativity and sightedness unless we impose some very strong additional assumptions. To see how this is so, let us redefine creativity as $c_i = y_i u_i (1 - v_i)$, but keep the definition of sightedness unchanged. Here y_i is the novelty of idea x_i. Now the inverse relation between creativity and sightedness is assured solely by the factor $(1 - v_i)$. Creative ideas must be surprising but sighted ideas must be obvious. To undermine this inverse relation demands that factor $(1 - v_i)$ be removed, with the unfortunate repercussions already treated in the previous section. Alternatively, the third factor can be retained in both definitions, but then require that y_i bear an inverse relation with $(1 - p_i)$ that is sufficient to cancel out the effects of p_i on sightedness, producing a zero relation between creativity and sightedness. Should we seek a positive relation between creativity and sightedness, then the negative relation between novelty and originality must be made even

stronger. Because originality is the inverse of probability, it should have become apparent by now that this argument has backed itself into a corner, introducing a serious reductio ad absurdum. To obliterate the inverse relation between creativity and sightedness necessitates that we assume that novel ideas are more probable and humdrum ideas are more improbable. This assumption is prima facie untenable. If novelty were so likely, creativity would be far more commonplace.

The bottom line is this: So long as novelty is positively correlated with originality, then creativity must be negatively correlated with sightedness. The modified relation may have become statistical rather than analytical, but the inverse relation remains an essential implication of any credible definitions of creativity and sightedness.[7]

Discussion

It has been firmly established that the inverse relation between creativity and sightedness follows logically from reasonable three-parameter definitions of creativity and sightedness. Because blindness is itself the opposite of sightedness—the two just representing opposing ends of a continuous scale—it can be equally inferred that highly creative ideas are more likely to be blind than sighted. That ideational blindness then mandates that ideas be generated and tested to determine their unknown utility values. These essential connections may have been what Campbell (1960) had in implicitly in mind when he first proposed the BVSR theory of creativity. Yet neither he nor his successors defined the central concepts with sufficient precision for the inevitable logic to become apparent.

That said, one might ask whether this analytical solution has rendered the whole question trivial. Has BVSR theory been reduced to a mere tautology? Is the position comparable to saying that "all bachelors are unmarried men," an analytical claim that has no empirical content? I believe that the answer is negative. The scatter plot showing the relation between bachelors and unmarried men would be completely uninteresting. Because there would be no bachelors who would be married men, the plot would have a single point. In contrast, the scatter plot indicating the predicted relation between creativity and sightedness is far more intriguing, even insightful. To be specific, any

plot of creativity as a function of sightedness would have to yield a roughly triangular joint distribution (for a supportive Monte Carlo simulation, see Simonton, in press-a). At the sighted end of the scatter graph, all ideas will have low creativity, whereas toward the blind end of the graph, ideas will vary from the most to the least creative. Stated differently, the variance in the creativity index increases as the sightedness metric decreases, or, more formally, as $s_i \to 0$, $\text{var}(c_i) \to 1$.

A more subtle implication concerns the univariate distribution of scores on the creativity index: These must display a strong positive skew, with the most creative ideas found on an extended tail on the extreme right of the distribution (again, see Simonton, in press-a). By comparison, the left side of the distribution will be replete with ideas with little or no creativity whatsoever. This prediction comes directly from the multiplicative definition of creativity. For any set X of k ideas, c_i must have a far more skewed distribution than the three factors $(1 - p_i)$, u_i, and $(1 - v_i)$ from which it is computed. This outcome holds even when the three factors have symmetric distributions (e.g., uniform or normal). This distributional implication makes any highly creative idea a mere "needle in the haystack" that puts even more demands on the application of BVSR processes and procedures. Many will be called, but very few if any will be chosen.

These expectations fit what many creative individuals have themselves reported. For example, the economist and logician William Stanley Jevons (1877/1900) affirmed that

> it would be an error to suppose that the great discoverer seizes at once upon the truth, or has any unerring method of divining it. In all probability the errors of the great mind exceed in number those of the less vigorous one. Fertility of imagination and abundance of guesses at truth are among the first requisites of discovery; but the erroneous guesses must be many times as numerous as those that prove well founded. The weakest analogies, the most whimsical notions, the most apparently absurd theories, may pass through the teeming

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[7] Nor is the problem resolved by substituting additive for multiplicative definitions of creativity and sightedness. The latter pair would still be negatively correlated, even if not as strongly. Without introducing downright arbitrary definitions, it is impossible to imagine creativity being positively associated with sightedness and hence negatively associated with blindness.

brain, and no record remain of more than the hundredth part. (p. 577)

Similarly, Michael Faraday, the physicist and chemist, observed:

> The world little knows how many thoughts and theories which have passed through the mind of a scientific investigator have been crushed in silence and secrecy by his own severe criticism and adverse examinations; that in the most successful instances not a tenth of the suggestions, the hopes, the wishes, the preliminary conclusions have been realized. (Beveridge, 1957, p. 79)

To a certain extent, then, highly creative ideas are contingent on chance or "luck." It comes as no surprise that Campbell (1960) quoted Alexander Bain's (1855/1977) claim that "the greatest practical inventions [are] so much dependent upon chance [that] the only hope of success is to multiply the chances by multiplying the experiments" (p. 597). If Faraday's estimate is correct, then it will take 10 experiments to produce one creative idea.

Although I hope this formal treatment prove useful in resolving a decades-old controversy, I would be the first to admit that the analysis remains oversimplified. One obvious simplification is that it ignores the fact that BVSR most often must operate as a sequential procedure (cf. Simonton, 2011b, 2012a). Another simplification is that the analysis takes place without regard to the specific discipline in which creativity takes place. Yet we have abundant reasons for believing that the prominence of BVSR creativity varies across domains (Simonton, in press-b). For example, BVSR plays a bigger role in the arts than in the sciences; and within the sciences, BVSR has a more critical function in the social sciences than in the natural sciences. Therefore, a more exhaustive analysis must allow for these additional complications. Even so, it is hard to imagine a state of affairs that would negate or even reverse this article's main claim: Because creativity is inversely related to sightedness, BVSR must separate the wheat from the chaff in the blind end of the distribution.[8]

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[8] Because my focus in this article is on the underlying logic of the BVSR-creativity relationship, I have ignored the empirical evidence in its support. This evidence has been reviewed at length in Simonton (1999) and Simonton (2010). The latter also uses combinatorial models to translate BVSR into a hypothetico-deductive theory yielding comprehensive and precise predictions that have so far received empirical support.

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