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The Blind-Variation and Selective-Retention Theory of Creativity: Recent Developments and Current Status of BVSR

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ABSTRACT
This article provides an update on the blind-variation and selective-retention theory of creativity (BVSR), beginning with an overview of its historical development. That brief narrative is then followed by a more extensive summary of recent enhancements in BVSR's conceptual foundations, including formal definitions of creative, sighted, and blind variations. These enhancements show that BVSR follows as a direct corollary of the three-criterion definition of personal creativity (i.e., the multiplicative function of originality, utility, and surprise). After treating the various types of BVSR as well as the diverse processes and procedures that can generate blind variations, discussion turns to a concise treatment of BVSR's research implications, which entail both theoretical extensions and empirical investigations. The article closes with an evaluation of the theory's current status. Whatever BVSR's limitations, it still captures an essential feature of creativity that is not sufficiently treated by any theoretical alternatives.

ARTICLE HISTORY
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Using objective assessments of disciplinary impact, Donald T. Campbell has been ranked 20th among the 100 most eminent psychologists in the Post-World War II era (Diener, Oishi, & Park, 2014). His rank stands higher than those of other modern psychologists who have contributed conspicuously to the creativity literature. In particular, Robert Sternberg ranked 60th, Howard Gardner 74th, and J. P. Guilford 97th. Only Herbert Simon and Carl Rogers, ranked at 11th and 12th respectively, might count as more eminent, if Simon and Rogers are to be considered creativity researchers. To be sure, Campbell's impact on psychology is largely attributed to his methodological contributions, most notably his work on quasi-experimental designs and the multitrait-multimethod matrix (e.g., Campbell, 1969; Campbell & Fiske, 1959; Campbell & Stanley, 1966). Even so, he made one theoretical contribution that continues to exert an impact on contemporary creativity research, namely, his blind-variation and selective-retention (BVSR) theory published more than six decades ago (Campbell, 1960). Yet at the same time, BVSR theory has undergone major developments over the intervening years (e.g., Simonton, 2011b). These developments are so substantial that the contemporary version might hardly be recognizable to the theory's originator. Tellingly, the theory's own evolution may itself have taken place according to BVSR's basic tenets: the selective retention of numerous blind variations (cf. Campbell, 1965, 1974b; see also Wasserman, 2021).

The present article begins with an overview of BVSR's historical development. This brief narrative is then followed by a presentation of recent enhancements in BVSR's conceptual foundations. The latter section then leads to a concise treatment of BVSR's research implications. This article closes with an evaluation of the theory's current status.

Historical development

At time of this writing, Campbell's (1960) article on "Blind Variation and Selective Retention in Creative Thought as in Other Knowledge Processes" has received well more than 3000 citations. By comparison, Mednick's (1962) paper on "The Associative Basis of the Creative Process," which was published in the same top-tier journal about the same time, has received more than 5500 citations. Although there are probably many reasons for this contrast in impact, two reasons may stand out. First, Mednick's theory was directly tied to a measure that became one of the most commonly known in creativity research, namely the Remote Associates Test (or "RAT").[1] Theoretical

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Author Note: Readers should probably be advised that the current author is the "doctoral grandson" of Donald Campbell, having earned his PhD with David A. Kenny, who had received his own PhD from Campbell. Nevertheless, despite once conversing with Campbell over dinner at the very time that he was working on his evolutionary epistemology, this author never discussed BVSR with its creator. Hence, no first-hand knowledge can be claimed.

Table 1. Journal target articles concerning BVSR creativity theory and specific applications.

Target articles	Journals	Commentaries	Replies
Campbell (1960) via Simonton (1998)	*Journal of Creative Behavior*	Perkins (1998), Sternberg (1998)	Cziko (1998)
Simonton (1999b): theoretical integration	*Psychological Inquiry*	Ericsson (1999), Martindale (1999), Russ (1999), Schooler and Dougal (1999), Sternberg (1999)	Simonton (1999a)
Simonton (2007a): Picasso case study (*Guernica* sketches)	*Creativity Research Journal*	Beghetto and Plucker (2007), Gabora (2007), Mumford and Antes (2007), Weisberg and Hass (2007)[1]	Simonton (2007b)
Simonton (2010a): combinatorial models	*Physics of Life Reviews*	Dasgupta (2010), Gabora (2010), Kaufman (2010), Nickles (2010), Runco (2010)	Simonton (2010b)
Simonton (2015c): Edison case study (patent trajectories)	*Psychology of Aesthetics, Creativity, and the Arts*	Gabora (2015), Weisberg (2015a)	Simonton (2015b)

[1]Doyle (2008) added a commentary on the same target article in the following year.

contributions receive an extra boost when they can inspire empirical research, and Campbell inspired no corresponding psychometric measure, his marked methodological expertise notwithstanding. Second, Campbell's interest in creativity was largely epistemological. As implied by the title, the phenomenon was grouped in the more inclusive context of "knowledge processes." In line with this orientation, he devoted considerable attention not to contemporary psychological research but rather to the more philosophical writings of Bain (1855), Souriau (1881), Mach (1896), and Poincaré (1921). Even worse, Campbell may have added relatively little to what these predecessors had already said (Martindale, 2009).

Of the two theories, Campbell's (1960) might have proved the more controversial, with debates on its merits extending over the next half century, and at times the arguments getting intense (Simonton, 2011b). Moreover, given his epistemological emphasis, this controversy engaged philosophers as well as psychologists. Indeed, the philosophical interest in his ideas became accentuated when he developed his evolutionary epistemology a little more than a dozen years later (Campbell, 1974a). Although some philosophers have expressed opposition to BVSR (e.g., Kronfeldner, 2010; Thagard, 1988, 2012), perhaps a majority can be said to be more sympathetic, even if with various qualifications (e.g., Bradie, 1995; Briskman, 2009; Heyes & Hull, 2001; Kantorovich, 1993; Nickles, 2003; Stein & Lipton, 1989; Wuketits, 2001). Facilitating this positive response are the strong correspondences between Campbell's ideas and the nearly simultaneous ideas of Karl Popper (1963), the well-known philosopher of science.

The reception of Campbell's (1960) BVSR by psychologists who actually studied creativity was less conspicuous, at least initially. However, starting in the mid-1980s, and accelerating into the 1990s and the following millennium, Simonton became the most prominent psychological proponent of BVSR, as judged by the sheer number of published articles, chapters, and books (e.g., Simonton, 1985, 1988b, 1999c, 2011a, 2015c). Simonton's advocacy often took the form of target articles that attracted commentaries from some of the leading figures in creativity research, as shown in Table 1. Furthermore, Simonton attempted to develop BVSR both as a comprehensive predictive and explanatory theory of creativity (e.g., Simonton, 2009a) and as a theoretical framework for conducting case studies of outstanding creativity, such as Galileo Galilei, Thomas Edison, and Pablo Picasso (e.g., Simonton, 2012b). So extensive were these efforts that sometimes even eminent researchers have conflated Simonton and Campbell, such as Eysenck's (1995) reference to the "Simonton-Campbell" chance-configuration theory when Campbell had nothing to do with it (cf. Campbell, 1960, versus Simonton, 1988b).

In retrospect, it has become evident that Simonton's developments of BVSR were not always beneficial to the cause, either theoretically or empirically. On the theory side, Simonton made changes in Campbell's (1960) BVSR that were clearly unwarranted. Most strikingly, despite the fact that Campbell bent over backwards to ensure that his theory was not based on Darwin's theory of evolution – Campbell didn't even cite Darwin! – Simonton made that connection explicit very early on, calling BVSR "Darwinian" (Simonton, 1999b). In line with this conceptual link, Simonton equated "blind variations" with "random variations" when Campbell never claimed that BVSR required that the variations be random (cf. "chance permutations" in Simonton, 1988b). On the empirical side, Simonton's endeavors to derive falsifiable implications sometimes did so at the expense of Campbell's original theory. The most striking example was converting the application of BVSR from "thought trials" to entire creative products (Simonton, 1985). The latter entities have the advantage that they can be more easily observed and measured empirically. By shifting the unit of analysis, Simonton then formulated empirically testable predictions, such as the "constant-probability-of-success model" (Simonton, 1988a), an awkward term that was later changed to the "equal-odds rule" (Simonton, 2003b) or "equal-odds baseline" (Simonton, 2010a; cf. "random impact rule" in Sinatra, Wang, Deville, Song, & Barabási, 2016). Not only was productive quality to be a positive function of quantity, but the ratio of hits to total attempts was supposed to be uncorrelated with quantity (cf. "strict equal odds" in Forthmann, Szardenings, Dumas, & Feist, 2021).

Not surprisingly, these theoretical and empirical distortions of Campbell's (1960) BVSR are what attracted the most criticism. Certainly many researchers objected to the very idea that creativity might be considered Darwinian (e.g., Dasgupta, 2004, 2011; Gabora, 2005, 2011; Weisberg, 2015; cf. Simonton, 2005). One eminent psychologist even referred to BVSR creativity as a "conventional religious faith" rather than a bona fide scientific theory (Sternberg, 1999). Moreover, Simonton's (2003a) effort to extricate BVSR from these objections by distinguishing between primary and secondary Darwinism went nowhere. In addition, the misleading extrapolation from thought trials to creative products led to several empirical inquiries that challenged the equal-odds rule or baseline (e.g., Forthmann, Szardenings, & Dumas, 2021; Hass & Weisberg, 2009; Kozbelt, 2008). These and other adverse developments obliged Simonton to return to Campbell's (1960) original article. It was then appreciated why Campbell not only did not cite Darwin, but also ignored James (1880), who had offered an explicitly Darwinian theory of creativity eight decades earlier (Simonton, 2018a). As Martindale (2009) pointed out in a review of evolutionary theories of creativity, the ideas of Bain 1855 prove that a BVSR-type theory can be conceived without any reference whatsoever to Charles Darwin. That possibility is proven because Bain published before Darwin presented his variation-selection theory to the world.

There's a hidden irony in Martindale's (2009) assertion, for he was apparently unaware of an episode in Darwin's life that might have dramatically altered intellectual history (Simonton, 2010b, based on http://darwin-online.org.uk/). While Darwin was in the midst of writing his *Origin of Species*, a family friend, a certain Fanny, recommended that he read Bain's book. We don't know why, but perhaps it was because she saw some resemblances between Bain's and Darwin's ideas. Darwin dutifully purchased the volume, put it on his library shelf, and never read it! If Darwin had gotten around to reading Bain, later researchers might be debating whether the theory of evolution by natural selection could most properly be called "Bainian" – based on an analogy with human creativity!

Conceptual foundations

Rather than call BVSR "Darwinian," it's more reasonable to subsume both BVSR creativity and Darwinian evolution under the more encompassing "universal selection theory" (Cziko, 2001). However, that hierarchical assignment appears less warranted in the case of BVSR owing to the inadequacies in Campbell's (1960) presentation. Rather than precisely define what counted as a "blind variation" he simply gave examples and a few suggested criteria – surely more connotative than denotative. Campbell must have eventually realized that the term "blind" was problematic, for he much later tried to substitute the adjective "unjustified" to describe the variations required (Campbell, 1974b). Unlike the earlier term, its substitute has a long history in epistemology, one that dates back to Plato's discussion of knowledge as "justified true belief" in his dialogue *Theaetetus*. But polysyllabic rather than monosyllabic, the adjective seems cumbersome, and never stuck.

Worse still, Campbell never provided an explicit definition of creativity (cf. Mednick, 1962, who did). This omission turns out to be critical because it will be shown that if he had done so, the definition of "blindness" might have followed as a logical extension. That inference will become apparent in the next three sections where three kinds of variations are defined: creative, sighted, and blind.

Creative variations

Creativity research can be easily considered a low-consensus domain, perhaps even lower than psychology as a whole (see Simonton, 2015a). One particularly potent piece of evidence for this low placement is the fact that researchers do not display a strong agreement on creativity's very definition (Plucker, Beghetto, & Dow, 2004). How can a domain reach consensus on theories, measures, methods, and results without first agreeing on the subject of investigation? To be sure, many investigators would claim adherence to what has been styled the "standard definition," namely that to be creative an idea (or response) must be both original and effective (Runco & Jaeger, 2012). Yet even here confusion often intrudes. For instance, researchers are not always clear about *who* is assessing originality and effectiveness, just the creators themselves or is some consensual endorsement required? The two assessment sources are too often conflated, as if the difference doesn't matter, which is extremely unlikely in low-consensus domains, especially in the arts (Brandt, 2021; Simonton, 2015a). Physicists might have a reasonable idea of how colleagues would evaluate their ideas, but that's less likely for psychologists, and even more improbable for poets. Hence, the most judicious procedure is to split creativity assessments into the personal and the consensual under the assumption that they may not correspond (Simonton, 2018b). Note, too, that the focus of BVSR must be on personally assessed creativity because the creator often must start with a judgment of what is even worth communicating to others before seeking a consensual evaluation (cf. James, 1880). Once that communication takes place, then the variation that survived personal testing is subjected to all of the complexities associated with sociocultural evolution, which entails many processes that have nothing whatsoever to do with individual creativity (Mesoudi, 2011). The idea then no longer belongs to its creator.

Yet it's necessary to go a step further because the standard definition only provides the necessary but not sufficient basis for judging personal creativity (Simonton, 2018b). In fact, some researchers have suggested the need for three criteria rather than two, such as Boden's (2004) novel, valuable, and surprising (see also Thagard, 2012), which readily maps onto the new, useful, and nonobvious criteria applied by the US Patent Office at the consensual level, for "obvious" is just the inverse of "surprising" (Simonton, 2012c; see also Sawyer, 2008). By adding this third criterion, we not only get a more complete creativity definition – one *both* necessary *and* sufficient – but also obtain more ways to distinguish non-creative ideas (Simonton, 2018b; Tsao, Ting, & Johnson, 2019). The latter provision is important because "blind variations" can adopt many forms besides just not being creative. Let's now start with a formal presentation of the derivation.[2]

At the beginning of a particular BVSR episode, a specific creator generates "variations." These represent various "thought trials," which shall be extended to encompass behavioral responses when applicable. Each variation may share one or more elements with other variations, but that may not always hold, such as after a problem undergoes restructuring or reframing. So in that sense, the term is only approximate, or metaphorical. It matters little for the variations might just as well be called ideas, combinations, potential solutions, trials, experiments, conjectures, hypotheses, operants, or some other term found in the literature. In any event, let a given variation be defined by the following three *subjective* parameters (i.e., holding exclusively within a single individual's head):

(1) The *initial* generation probability p (where $0 \le p \le 1$); e.g., the variation is instantaneous ($p = 1$), requires an "incubation" period ($p = 0$), or somewhere between, like after an hour or two of intense work ($p \approx .5$). In conceptual terms, p would correspond inversely to generation order (e.g., Simonton, 2007a) or response latency (e.g., Bowden & Jung-Beeman, 2003), albeit in actual research a data transformation would be required to convert an ordinal or ratio scaled variable into a 0–1 continuum. Importantly, the subjective *originality* of the idea or response can be then defined by $(1 - p)$.

(2) The *final* utility u, as determined at the time the creative product is fixed (where $0 \le u \le 1$); e.g. the proportion of usefulness criteria met in the ultimate product, where usefulness can involve value, meaning, effectiveness, etc. Thus, Thomas Edison's quest for a viable incandescent lamp filament required that it satisfy several distinct specifications, but a given test filament would often fail by one or more criteria, like durability (Simonton, 2015c). Naturally, the utility can often assume dichotomous 1 or 0 values, indicating that an idea or response either succeeds or fails. This discrete nature is especially common in laboratory experiments concerning insight and problem solving (e.g., the classic "two-strings" problem in Maier, 1931).

(3) The person's *prior* knowledge of that final utility, v (where $0 \le v \le 1$); e.g., ignorance ($v = 0$) to educated guess ($v \approx .5$) to full expertise ($v = 1$). Like the initial probability, this parameter can be inverted as $(1 - v)$ to produce a very useful construct, namely *surprise* (or "nonobviousness"). In effect, this gauges how much new knowledge about the utility is acquired after that utility is assessed (for a more formal analysis, see Tsao et al., 2019).

Then the *personal* creativity of the variation is given by the multiplicative function:

$c = (1 - p)u(1 - v)$, again $0 \le c \le 1$.

In words, a variation's subjective creativity requires that it be simultaneously original, useful, and surprising, where the multiplicative function ensures that unoriginal, useless, and/or obvious variations cannot be deemed creative. That signifies that variations can be non-creative seven different ways (Simonton, 2018b). As might be expected, the above definition also implies that maximizing creativity is extremely difficult. To illustrate, if $p = .1$ (low initial probability and hence highly original), $u = .9$ (not optimally useful but pretty close), and $v = .5$ (prior utility knowledge was at an informed hunch level), then $c = .41$, which is only about two fifths up the theoretical scale. Highly creative variations should be few and far between, implying that some selection is requisite before retention. Indeed, it requires a relatively rare event, namely an extremely valuable serendipitous discovery, to maximize creativity, for only then can $p = v = 0$ while $u = 1$, yielding $c = 1$ (for detailed analysis, see Simonton, 2022).

Sighted variations

Many opponents of BVSR have argued that creative variations are highly sighted, directed, or guided, but do so without defining what sightedness exactly means (e.g., Sternberg, 1998; cf. Kronfeldner, 2010, versus Thagard, 2012, whose definitions do not agree). Yet given the above three variation parameters, the degree of variation sightedness can be plausibly defined as $s = puv$, yielding perfect sightedness at $p = u = v = 1$. Expressed verbally, a perfectly sighted variation has an initial probability of unity because it has a utility of unity and that maximal utility is already completely known. A variation of this kind cannot possibly be creative, for it represents routine or habitual thinking. It is literally the first thing that comes to mind, and stays there because it meets expectations perfectly (i.e., automaticity; Simonton, 2016). It can easily be shown, both mathematically and via Monte Carlo simulations, that variation creativity is inversely associated with variation sightedness (e.g., Simonton, 2012a, 2013b). Stated simply, as p, u, and v all go to 1, c necessarily goes to 0, despite the fact that both s and c cannot maximize without $u = 1$.

Because creativity usually operates within a domain, like painting or chemistry, sightedness can be considered a gauge of the extent to which the variation represents domain-specific expertise. For example, when a mathematician needs to find the roots of a quadratic equation, they just plug in the three coefficients into the quadratic formula and then do the arithmetic, knowing full well that the roots obtained are correct assuming no dumb mistakes. Thus, variations where $s \rightarrow 1$ can be designated instances of *explicit expertise* (where "→" indicates "approaches" or "nears").

Nonetheless, it's possible that some BVSR opponents have something else in mind, namely, that variations will not be generated that violate domain-specific expertise. If so, these can be defined using the same parameters: when $p \rightarrow 0$, $u \rightarrow 0$, and $v \rightarrow 1$. In words, a particular variation has an extremely low probability because it is already well known that it has a minimal utility. This "preselection" no doubt happens very often, and such events may be said to illustrate *implicit expertise*. Even so, such variations are not creative because they lack utility, a deficiency that's known a priori. For example, no contemporary chemist would even dream of introducing phlogiston theory to explain an observed reaction. Consequently, this second conception of sightedness appears trivial.

Although sightedness and creativity are in clear opposition, the end result of creativity is to enhance sightedness. To offer the extreme case, if someone confirms a serendipitous discovery with the parameters $p = v = 0$ and $u = 1$, like Archimedes reportedly did in the first recorded Eureka episode, then the *posterior* probability and utility knowledge will become perfectly sighted $p = v = u = 1$ (Simonton, 2022; see also Tsao et al., 2019). Accordingly, creativity's outcome is to increase explicit expertise, but it can only get there via BVSR, as shown next.

Blind variations

Using the same three variation parameters, blindness can be defined more than one way (Simonton, 2011a, 2013b; Tsao et al., 2019).[3] But the most elegant, and arguably the most consistent with Campbell's (1960) epistemological intuition, is adopted here, namely just using v, the creator's prior knowledge of the variation's utility, whatever that utility may be (Simonton, 2021). Hence, a variation is blind to the extent that $v \rightarrow 0$, and thus making the utility value surprising, or $(1 - v) \rightarrow 1$, which necessarily requires that sightedness $s \rightarrow 0$ as well (i.e., maximal blindness necessitates minimal sightedness). When $v \rightarrow 1$, the values of p and u are highly constrained, because p and u must then positively correlate for any rational person, thereby obliging either explicit expertise or implicit expertise (Simonton, 2016). But for highly blind variations, the other two parameters become independent, and thus perfectly free to assume diverse possibilities, yielding four representative manifestations (cf. Simonton, 2011a, 2016; Tsao et al., 2019):

(1) *Problem finding* ($p \rightarrow 1$, $u \rightarrow 0$, but $v \rightarrow 0$): Here the variation that enjoys the highest initial probability is one that suffers the lowest utility, so what was expected to work doesn't work at all. An example would be a firm prediction from a well-established theory that is surprisingly disconfirmed (i.e., surprise can work both ways). In other words, this variation can be considered a would-be sighted variation that is proven useless.

(2) *Lucky guess* ($p \rightarrow 1$, $u \rightarrow 1$, but $v \rightarrow 0$): This variation also has the highest probability, but also features the highest utility, yet that utility is not truly known in advance (e.g., "right for the wrong reason"). At best, this variation extends the scope of current knowledge, such as discovering that a commonly used catalyst will work for a novel chemical reaction without any sound knowledge about why it even should do so. Because saying "all I know is that it works" cannot count as a justified true belief, the creator should try to figure out what went right in order to defend the outcome to colleagues, and thereby enter another

BVSR episode. Otherwise it may emerge that the variation's success was a fluke, only working under unreliable circumstances.

(3) *Mind wandering and tinkering* ($p \rightarrow 0$, $u \rightarrow 0$, and $v \rightarrow 0$): Here original thoughts or behaviors are generated with no expectation of usefulness – like just fantasizing or toying around at the keyboard. Even if these variations are almost always useless, because their generation mechanism is ignorant of their utilities, that very ignorance prevents high utility variations from getting filtered out, and consequently highly useful variations can inadvertently emerge, which then results in the fourth and final blind variation.

(4) *Creativity* ($p \rightarrow 0$, $u \rightarrow 1$, and $v \rightarrow 0$, so $c \rightarrow 1$): Significantly, if Campbell (1960) had carefully defined both creativity and blindness, he would have been able to prove that all creative variations must entail a substantial amount of blindness. In fact, in the special case where originality and usefulness are already maximized (i.e., $1 - p = 1$ and $u = 1$), the creativity of a variation is directly proportional to the degree of surprise (i.e., $1 - v$). Accordingly, BVSR becomes a necessity, the more creative the variation the greater the necessity. If the utility is unknown, it must be determined. In contrast, highly sighted variations do not require a utility evaluation, but then they are not likely to display any creativity (Simonton, 2013a). Even a variation based on a partially substantiated guess, such as $v = .20$, has its creativity reduced by a fifth. Clearly, in maximizing creativity, ignorance is bliss – that's what underlies true discovery.

Obviously, the first two blind variations will be tried first, if any exist in the creator's response repertoire. Although a lucky guess could possibly terminate BVSR (even if lacking epistemological warrant), a problem-finding variation will most likely motivate continued BVSR. Similarly, a creative variation, if sufficiently creative, will probably end BVSR, whereas mind wandering and tinkering will likely keep BVSR going, even if intermittently as default or resting states, or episodes of pure play.

At this point, it should have become manifest why all three parameters – namely, p, u, and v – are absolutely mandatory for a complete description of creative phenomena. The prior knowledge of the utility at the moment of variation generation is no less essential than the other two. For example, if v is omitted, then a lucky guess is indistinguishable from explicit expertise, thus conflating a blind variation with a sighted variation when those two are manifestly distinct.

Admittedly, some researchers might still wonder how originality, or low probability, can be separated from surprise. Aren't all improbable variations inherently surprising? The answer is no, because some improbable variations are easy to *assimilate* into the person's existing knowledge, whereas other improbable variations force the person to *accommodate* the new information by modifying what they know. Indeed, philosophers have specifically dealt with this issue and concluded that the two phenomena must be kept separate (Shogenji, 2021). A low-probability event will not surprise if it remains "proximate" to expectation. To offer a simple illustration, if a random number generator yields the 10 consecutive digits 5446322662 that is not surprising (in fact, they were taken straight from a table of 10,000 random numbers), but if it instead yields 9999999999 (a sequence not found anywhere in that multiple-page table), that would be quite surprising, even though the two sets of digits have precisely identical probabilities. The second sequence would lead one to suspect that the generator program has a bug or the computer has been hacked – an accommodation rather than assimilation. This essential distinction between originality and surprise also endorses the insistence of the US Patent Office that a new and useful invention also be nonobvious to anyone with "ordinary skill in the art" (i.e., someone with the relevant expertise; Simonton, 2012c). What's surprising to a novice is not so to an expert (e.g., who can calculate the probability of 10 random digits).

Now that the creative significance of blind variations has been deduced from the three-criterion definition of creativity, it's necessary to deal with two subordinate questions. First, what are the various ways that BVSR operates in human creativity? Second, what are the processes and procedures responsible for the blind variations at the outset?

BVSR varieties

Because human creativity is so much more complex than biological evolution, it manifests itself in diverse ways (Simonton, 2011b). To indicate this variety, consider three contrasts. First, the blind variations may be presented for selection simultaneously, much like occurs in Darwinian evolution, or presented sequentially, such as happens in Skinnerian operant conditioning (Skinner, 1981). Second, the evaluation of blind variations may occur either externally, as tests against the observed world, or internally, as tests against acquired mental representations of that world (cf. "Skinnerian" versus "Popperian" in Dennett, 1995). Third, the overall strategy may involve either exploration or elimination (Simonton, 2013a). In the former case, the creator does not know in advance whether even one variation exists that satisfies the given utility criteria (i.e., $v = 0$ for every variation); in the latter case, the creator knows that at least one among the k variations will work (i.e., $v > 0$ for every variation, but $v \rightarrow 0$ for each variation as k increases). For example, when a paleontologist sets up a site to search for hominid fossils without any prior information that guarantees that they be found there, that entails exploration. Yet when James Watson used molecular models to learn how the four DNA bases would line up in the double helix interior, he knew in advance that one of the four available combinations would work, so he just had to identify that one combination that had the right fit (i.e., $v \approx .25 = ¼$ per variation; N.B. Watson did not use Chargaff's rules which would have rendered his search far more sighted; Simonton, 2013a).

In theory, then, with the above three contrasts, there are eight ways that BVSR might operate, even if some of these are far more possible than others. All eight are shown in Table 2, with an example corresponding to each. The only truly problematic BVSR varieties are those involving simultaneous and internal selection, whether exploration or elimination. The difficulty arises from the limitations on human working memory, which would be expected to evaluate at least two internal representations at the same time. That possibility is probably easiest to achieve for those who enjoy extremely good visual imagery when applying BVSR to relatively simple variations in that modality. Visual artists likely do this most often.

Table 2. Eight varieties of BVSR: differential timing, location, and strategy.

Timing	Location	Strategy	Example
Simultaneous	External	Exploration	Implementing a clinical trial of three alternative and previously unevaluated medical interventions
		Elimination	Testing two mutually exclusive theoretical predictions, one of which has to be true
	Internal[1]	Exploration	Comparing alternative representations for a figure in a painting, such as facing left or right
		Elimination	Same as preceding, but with prior knowledge that one of the two representations has to work
Sequential	External	Exploration	Sifting a paleontological site for certain fossils without prior assurances that they even exist there
		Elimination	Excavating an archeological site for an artifact that is known to be there from extant documents
	Internal	Exploration	Conducting successive Gedanken experiments to evaluate the implications of some assumptions
		Elimination	Calculating some ballpark estimates to determine the most likely best-fit parameter value

[1]True simultaneous internal BVSR is probably extremely rare given the limitations on working memory; representation switching or mental rotation more likely except when images are extremely basic (e.g., color patches or geometric figure orientations).

Variation processes and procedures

If creativity researchers display such minimal consensus regarding the very definition of their subject matter, it would be too much to expect the same researchers to agree on any inventory of creative processes and procedures. In line with this suspicion, it has become apparent that creativity investigators have identified numerous and often quite disparate mechanisms that lead to creative outcomes (Simonton, 2017). Table 3 provides some examples, without any attempt to be exhaustive or to separate out any semantic overlap between terms, and just listed in alphabetical order to avoid playing favorites (but see Dietrich, 2019, for a possible typology). Yet what is shown there certainly suffices to demonstrate that creativity involves an impressive variety of processes and procedures. Moreover, there is sufficient evidence to believe that all of those listed, and perhaps more, work *some of the time*, but absolutely none of them works *all of the time*. Hence, the best recommendation is to use whatever works (cf. "anything goes" in Feyerabend, 1975; see Russell, 1983). This necessary ignorance echoes the No Free Lunch Theorems in algorithmic problem solving (Wolpert & Macready, 1997),

Table 3. Creative processes and procedures suggested in the research literature (Alphabetical order).

Mechanism(s)	Sample citations
abductive reasoning	Güss, Ahmed, and Dörner (2021)
bisociation	Koestler (1964)
cognitive disinhibition or defocused attention	Carson (2014); Martindale (1995)
combinatorial play (cognitive)	A. Einstein (in Hadamard, 1945)
constrained stochasticity or stochastic search	Carruthers (2020)
divergent thinking	Guilford (1967)
forward flow	Gray et al. (2019)
geneplore	Finke, Ward, and Smith (1992)
heuristic search (analogy, hill-climbing, means-end analysis, working backwards, etc.)	Langley, Simon, Bradshaw, and Zythow (1987); Newell and Simon (1972)
insight	Hélie and Sun (2010)
intuition or unconscious thought	Bowers, Regehr, Balthazard, and Parker (1990)
janusian, homospatial, & sep-con articulation thinking	Rothenberg (2015)
mind wandering & daydreaming	Gable et al. (2019)
ordinary thinking	Weisberg (2014)
primary process or primordial imagery	Martindale (1990); Suler (1980)
remote association	Mednick (1962)
serendipity (both true & pseudo)	Copeland (2019)
systematic search (e.g., scans, grids, enumerations)	Campbell (1960)
tinkering and play (behavioral)	Kantorovich (1993)

which may be summarized as "All optimization algorithms perform equally well when averaged over all possible problems" (D. Simon, 2013, p. 614; see also Nickles, 2003). The implication is that BVSR must often participate at two levels: first, the separate variations and second, the several means by which variations can be generated. The latter might be called *meta-BVSR*. For instance, once despairing of finding a useful analogy after deliberately trying out several possibilities, a creator might resort to some other procedure listed in Table 3, such as means-end analysis, before just lapsing into mind wandering – which process then provides the long sought-for ah-ha experience!

That said, meta-BVSR only uses processes and procedures that can generate blind variations for subsequent selection and retention. Accordingly, the mechanisms listed in Table 3 must all supply variations that will very likely prove useless (see, e.g, Simonton, 2011b). In fact, they can all be categorized in the problem-solving literature as "weak methods," which cannot guarantee success, in contrast to the "strong methods" represented by domain-specific algorithms (Klahr, 2000; cf. "heuristic" versus "algorithmic" tasks in Amabile, 1996). The quadratic formula never fails to provide the correct answer, yet its usage entails no creativity (for s = 1). Even the most strikingly original roots, such as complex roots with both imaginary and real numbers, should fail to surprise (e.g., solve $x^2 + 4x + 5 = 0$).

Research implications

As noted earlier, Campbell's (1960) BVSR theory did not inspire as much creativity research as Mednick's (1962) associative theory. Perhaps another reason for that deficiency, besides the two mentioned back then, was the possibility that BVSR really has no implications that might inspire investigations. Moreover, this pessimistic possibility may have been aggravated by the earlier demonstration that BVSR follows logically from the three-criterion definition of creativity, for it now seems like a tautological proposition. Worse yet, Table 3 lists so many processes and procedures that can produce blind variations that BVSR might seem immune to falsification. At least superficially, BVSR could be criticized for the same reasons that Popper questioned the falsifiability of Darwinian evolutionary theory (for review, see Elgin & Sober, 2017). Furthermore, given psychology's placement in the hierarchy of the sciences (Simonton, 2015b), and the possibly lower status of creativity as a topic within psychology, it seems that no theory of creativity, BVSR or otherwise, would prove more scientifically secure than biology's theory of evolution by natural selection. True or not, BVSR, especially as presently revised, features definite implications for creativity research, including some predictions that render the theory falsifiable, perhaps even more so than Darwinian theory.

BVSR's implications can be grouped into two categories: (a) theoretical extensions and (b) empirical investigations.

Theoretical extensions

BVSR theory enjoys the special advantage that it doesn't specify a particular process or procedure (Simonton, 2011b). Any mechanism shown in Table 3 that can generate blind variations for subsequent selection and retention will qualify. As a result, BVSR can show up as a generic component of diverse theories of creativity. For example, BVSR appears in: (a) Martindale's (1990) theory of aesthetic evolution (where primordial imagery helps produce variations); (b) Kantorovich's (1993) theory of scientific discovery (where serendipity plays an important role; see also Kantorovich & Ne'eman, 1989); and (c) Staw's (1990) theory of innovation in organizations (which combines BVSR with Amabile's, 1988 componential model of creativity). Updated applications of Campbell (1960) that also incorporate recent developments from Simonton (1998, 2011b, 2013a) can be found in theoretical frameworks for understanding (a) the structure of creative cognition in the human brain (Jung, Mead, Carrasco, & Flores, 2013), (b) the relation between artistic and scientific creativity (Allen & Heaton, 2018), and (c) the nature of creativity in children (Kupers, Lehmann-Wermser, McPherson, & van Geert, 2019).[4] The last application shows that BVSR is by no means limited to adult creativity. In fact, BVSR is not even confined to creativity per se for it's possible to derive a formal basis for personal agency from the three-parameter definitions given earlier (Simonton, 2013c). In a nutshell, creative thoughts can generate acts of free will without violating the assumption that individuals live in a deterministic world. This possibility then becomes the basis for arguing that creative geniuses can become agents of historical change (Simonton, 2018a).

BVSR's generic nature also lends itself to the formulation of mathematical models of creative phenomena (e.g., Simonton, 2010a). These models are usually combinatorial in nature, and often assume a certain amount of randomness in the underlying creative mechanism, an assumption consistent with the fact that many processes and procedures certainly operate *as if* they are stochastic (Carruthers, 2020; Simonton, 2003b). Serendipity may provide the best example (Boden, 2004). Furthermore, the operation of meta-BVSR may introduce a chance feature insofar as the choice of alternative variation mechanisms will often prove capricious. In any event, BVSR mathematical models do an excellent job predicting key features of creative behavior, such as career trajectories (Simonton, 1997) and multiple discoveries (Simonton, 2010a). Needless to say, creativity theories that make precise but empirically confirmed predictions are rather rare in the field.

Another way to implement BVSR is to use the theory to design Monte Carlo simulations of creativity. In this case, of course, the simplifying assumption of randomness is made even more explicit. For example, Simonton (2012a) worked out the consequences of the three-parameter definitions of creativity and sightedness by generating a scatterplot between the two for 10,000 hypothetical combinations. Figure 1 shows the outcome. As expected, highly sighted combinations exhibit the lowest creativity; this area is where explicit expertise dominates. At the opposite end of the horizontal axis are found the most creative combinations, but also the largest variation in creativity, that variation then necessitating BVSR to separate the wheat from the chaff. Yet the scatterplot also indicates that a small amount of sightedness is not inconsistent with a small degree of creativity. For instance, a combination with the parameter values $p = .5$, $u = 1$, and $v = .5$ yields $c = s = .25$, which marks one quarter up both creativity and sightedness scales. But even within this portion of the scatterplot BVSR remains necessary because so many combinations will display little or no creativity (viz. $0 \le c \le .25$), as is easily apparent from viewing that portion of the graph. This illustrates how a creative variation can be equally "guided" and "blind" at the same time rather than requiring that they be mutually exclusive (see also Mesoudi, 2021; cf. Kronfeldner, 2010). Much creativity likely appears at this modest level.

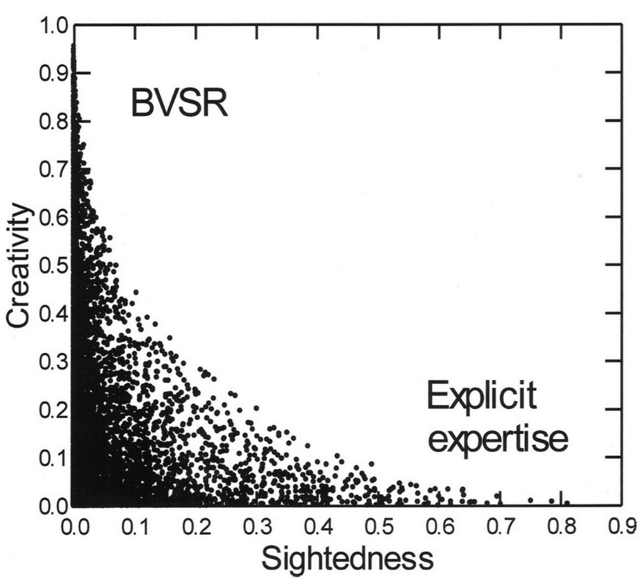

Figure 1. Scatterplot showing the theoretical relation between variation sightedness and creativity. Note. Monte Carlo simulation where sightedness $s = puv$ and creativity $c = (1 - p)u(1 - v)$ using the parameters p = initial probability, u = final utility, and v = prior knowledge of that utility. Regions where BVSR and explicit expertise predominate are indicated. Modified from Simonton (2013c). N.B.: The scatterplot changes minimally when p is rationally constrained to be no smaller than uv (i.e., $p \to 1$ as $uv \to 1$).

Finally, it's at least worth mentioning that computer programs inspired by BVSR-like principles, such as genetic algorithms and genetic programming, are strikingly successful in genuine problem solving (D. Simon, 2013). These programs are fundamentally combinatorial, albeit they usually attain blindness via randomness, like the preceding mathematical models and Monte Carlo simulations. Although Campbell (1960) did not inspire any of these developments, the results lend "proof of concept" support to BVSR. Creativity emerges out of ignorance – what he called blindness. This epistemological necessity will be returned to in the evaluation section.

Empirical investigations

The updated BVSR presented here makes some very specific predictions that can stimulate empirical research in various ways.[5] These predictions are based on the fundamental premise of variation blindness: the low to minimal prior knowledge of the utility at the moment that the variation is generated (i.e., $v \to 0$). This premise has two critical consequences.

First, the greater the degree of blindness, the larger the number of variations that will likely be generated before finding one with the desired utility, which may or may not even happen (except under elimination). This has been called variation *superfluity* (e.g., Simonton, 2015c). Because the creator doesn't know in advance whether a given idea or response will work, but must generate and test it first, many variations will prove useless or at least of highly variable low utility. As Bain, 1855 asserted, creativity is "so much dependent upon chance that the only hope of success is to multiply the chances by multiplying the experiments" (p. 597). This multiplicity of variations contrasts conspicuously with highly sighted variations, where the idea or response with the highest utility has the highest probability (explicit expertise), while other nominal possibilities have low or zero probabilities due to their already known poor utilities (implicit expertise). To be sure, sometimes more than one variation will prove sufficiently useful to feature a modestly high probability. For example, quadratic equations can be solved by factoring and completing the square, but these algorithms only work easily for a small subset of all possible equations. Another apparent exception involves iterative algorithms that start with an initial value and then produce a series of revised values that increasingly approximate the desired value within a given margin of error. The successive iterations clearly cannot count as independent blind variations because they are designed to become increasingly more sighted, each improving directly on the error yielded in the preceding.

Second, whenever blind variations are generated sequentially – the most common situation in human creativity – the correlation between their order of generation and their assessed utility will approach zero to the extent that the utilities are unknown in advance (cf. Campbell, 1960). In other words, the relation between variation utility and variation probability will be nonmonotonic, neither increasing nor decreasing but rather fluctuating unpredictably (Simonton, 2007a). Note that iterative algorithms necessarily violate this expectation because each iteration is ordered according to increased utility (i.e., goodness of fit). In contrast, random variations are guaranteed to be nonmonotonic, except for chance departures when the number of variations is small (e.g., if an unbiased coin is flipped only four times, it's not impossible that the first two come up tails and the last two heads). One special corollary of this second expectation of sequential BVSR is the phenomenon of *backtracking* (Simonton, 2015c). The creator may discover that a variation that had been evaluated earlier in the sequence turns out to feature the highest utility of the entire set of variations, obliging the individual to select and retain a variation previously put aside in the hope of getting something better. This backtracking is especially likely when the creator is willing to engage in *satisficing* rather than doggedly persist in the search for optimal utility, which may always remain elusive (H. Simon, 1956).The wish list that defines the utility criteria may include unachievable even if conceivable items.

Logically, if a creative episode includes one or both of the above, then BVSR is necessarily involved. Admittedly, occasionally BVSR may still operate even if neither holds. A manifest case is when a lucky guess ends the search right then and there. Or a person may generate one blind variation that fails to pass inspection, and then just gives up the quest, perhaps unable to conceive another option. Neither of these examples involve multiple variations, and without multiple variations it's equally impossible to exhibit nonmonotonic utility trends in sequential BVSR. Even so, highly creative people are less prone to give up their creativity so readily, and thus BVSR will most often show these two signs. No other route exists to the most creative ideas or responses.

Now let us turn to the implications for (a) cognition and behavior and (b) personality and development.

Cognition and behavior

The two implications mentioned above are implicit in Mednick's (1962) distinction between steep and flat associative hierarchies, where the former features just one or two associations with high response strengths and the latter features a half dozen or more associations with weaker and more equal response strengths (where "response strength" corresponds to initial probability). In fact, remote association has already been treated as a BVSR process (Suchow, Bourgin, & Griffiths, 2017). Each successive association is generated without knowing in advance whether it will connect with parallel chains of associations. If otherwise, then associations cannot possibly be remote (e.g., a proximate associate of "dog," "cat," and "parakeet" is "pet"). Most of the other processes and procedures listed in Table 3 have also been shown to exhibit similar properties, including both systematic and heuristic searches (Simonton, 2011b). Again, randomness is not required for blindness, just a means to generate ideas or responses in which the utilities are not already known.

To be sure, several of the mechanisms given in that table are less amendable to direct observation. Yet the sophisticated techniques of the cognitive neurosciences can tease out BVSR processes that might be otherwise overlooked. For example, mind wandering is not only associated with blind variations, owing to the parameter values described earlier, and empirically linked to creativity (Gable, Hopper, & Schooler, 2019), but also has been connected with the brain's Default Mode Network (Jung & Chohan, 2019). Brain imaging can also combine with behavioral measures to pin down more elusive BVSR manifestations, as seen in work showing not only that ideational quality (creativity) highly correlates with quantity (productivity) but also identifying specific brain regions associated with creative output (Jung et al., 2015).

Some laboratory experiments have attempted to test BVSR predictions, but have done so via misconceptions about BVSR's actual claims. To offer a recent example, one study tried to determine whether creativity is enhanced by exposure to randomness, and found no effect (Malthouse, Liang, Russell, & Hills, 2022). Besides the fact that BVSR doesn't require randomness, randomly presented stimuli are often too easily assimilated as just random, rather than obliging the participants so exposed to accommodate their thinking in a nontrivial fashion. For this reason, laboratory experiments show that creativity can be successfully stimulated using "diversifying experiences," that is, "highly unusual and unexpected events or situations that are actively experienced and that push individuals outside the realm of 'normality'" (italics removed; Ritter et al., 2012, p. 961). Other experiments that identify effective creativity stimulants can often be classified as involving diversifying experiences as manipulations (e.g. Chirico, Glăveanu, Cipresso, Riva, & Gaggioli, 2018; Rastelli, Greco, Kenett, Finocchiaro, & De Pisapia, 2022; Vohs, Redden, & Rahinel, 2013). The role of these special experiences will return in the next section.

A quite divergent empirical approach is to conduct case studies of historic creativity. Here notebooks, sketches, drafts, and other archival documentations provide detailed records of the actual thoughts that led to breakthrough discoveries or inventions. Although some research tended to emphasize the importance of domain-specific expertise in exceptional creativity (e.g., Weisberg, 2014), other inquiries demonstrated the necessity of BVSR to go beyond that expertise (e.g., Simonton, 2015c). For instance, both variation superfluity and backtracking are quite evident in the sketches that Pablo Picasso made in route to his famous *Guernica* painting (Damian & Simonton, 2011; Simonton, 2007a; see also Weisberg, 2004). Indeed, BVSR is even required to construct a new expertise where previously none existed, as in Galileo's creation of telescopic astronomy and Leeuwenhoek's invention of microscopic biology (Simonton, 2012b). Naturally, both Galileo and Leeuwenhoek originally faced severe skepticism from the domain-specific experts of their day. Neither innovator was supposed to see what they claimed to see.

One drawback of these single-case studies should be obvious: Although such studies can illustrate how BVSR can usefully explain creativity of the highest order, they cannot count as outright confirmations of the theory. In fact, it could be possible to identify specific cases that might seem to contradict BVSR, such as a poet who wrote an unprecedented masterpiece in one flash of inspiration, without any edits or later revisions whatsoever. Hence, it would be highly advantageous to compile a very large and representative sample of creative episodes in which there's sufficient documentation to determine whether variation superfluity and backtracking are the norm rather than the exception.[6] BVSR necessarily predicts the former. Not only should ideational quality be a probabilistic consequence of ideational quantity, but the quality of ideas should be more or less unsystematically distributed across successive trials. In contrast, if it generally holds that highly creative people characteristically get their best ideas on the first try and thus avoid having to pass through a long variation-selection process, then BVSR is effectively falsified as a general theory of exceptional creativity. To be sure, BVSR still might prove valid for everyday creativity, a possibility that would then require testing using more conventional methods, such as laboratory experiments and psychometric assessments (e.g., Jung et al., 2015). Yet those methods are perfectly capable of falsifying BVSR at that level.

Before ending this section, a special warning is due: The constant-probability-of-success model, equal-odds rule, or the equal-odds baseline cannot be taken as directly relevant to the empirical status of BVSR theory. As observed in the historical review, this principle was first introduced by Simonton (1985) when switching the unit of analysis from the thought trial to the eventual creative product. This switch in the analytical unit had no genuine justification then nor does it have any now. After all, creative products (a) always consist of ideas that constitute the selectively retained output of BVSR rather than its variational input and (b) usually contain multiple ideas of highly variable BVSR confirmed creativity organized into complex hierarchical structures. Perhaps only wall-poster aphorisms or advertisement jingles might consist of a single creative idea. In addition, research using products almost always relies on consensual judgments rather than the creator's personal assessments of their own work (cf. Kozbelt, 2007). So the evaluation is yet another step removed from what took place during the BVSR episodes that generated all of the ideas that entered into a particular creative product. Another difficulty is that it's not obvious why this model, rule, or baseline would even apply to Campbell's (1960) thought trials. Because he makes no comparable claim, this principle seems like another instance of Simonton misrepresenting the original theory by making it Darwinian. Even today, while it's obvious that BVSR dictates a positive quantity-quality association, it much less clear that the ratio of hits to total attempts should be constant across the full range of attempts (cf. diminishing returns). It was just assumed that these two aspects of BVSR creativity would be tantamount to the same thing. More than three decades later, that assumption was proven incorrect (Forthmann et al., 2021). Therefore, it's best to treat the model, rule, or baseline as a valuable question worthy of empirical pursuit, but not one that has immediate diagnostic implications in testing the validity of BVSR. That would not be fair to Campbell!

Personality and development

Previously it was noted that creative domains vary greatly in their magnitude of consensus (Simonton, 2015a). In fact, creative domains exhibit a clear hierarchy running in the following order: physical sciences, biological sciences, behavioral sciences, social sciences, humanities, and the arts (Fanelli & Glänzel, 2013; Simonton, 2009b). Moreover, this ordering governs the constraints that the domain imposes on BVSR creativity, meaning that BVSR is more prominent in the arts than in the sciences, and more conspicuous in the behavioral and social sciences than in the physical and biological sciences (Simonton, 2014). Another way of putting this relation is that explicit expertise plays a bigger role in the higher consensus domains. Hence, on the average, ideational originality tends to be less salient, utility criteria tend to be better defined, and the prior knowledge of the utility tends to be superior (Simonton, 2021). These differences not only govern personal creativity but also show up in the eventual publications in which the resulting ideas are communicated (Fanelli & Glänzel, 2013). At the extreme ends of the hierarchy the contrasts become obvious to even the most casual observer. Just compare a typical article in a top-tier physics journal with the typical poem appearing in a prestigious literary magazine. Even ignoring the mathematics, the former is permeated with expertise-driven templates and boilerplate, with many sentences tightly paraphrased from previously published articles, whereas the latter will usually consist of sentences that have never been seen before in literary history.

Now the degree to which a domain depends on BVSR will also correspond with both personality traits and developmental experiences that would be expected to nurture BVSR creativity (Simonton, 2014, 2021). One fundamental reason for this correspondence is that the contrasts in consensus ultimately reflect domain differences in the complexity of the phenomena that constitute their main subject matter (Simonton, 2015a). It is difficult to achieve consensus on theories, methods, and findings when the phenomena are so complicated as to justify multiple and even incompatible perspectives. Yet without that consensus, the influence of domain-specific expertise is weakened because there can be no agreement on what that expertise specifically entails. A classic example within psychology is the enduring division between experimental and correlational psychologies (Cronbach, 1957; Tracy, Robins, & Sherman, 2009), a division that permeates creativity research as well (Simonton, 2003b). Correlational psychologists believe that some phenomena within the domain are too complex to lend themselves to laboratory experiments (see also Sanbonmatsu, Cooley, & Butner, 2021; Sanbonmatsu & Johnston, 2019).

So what are the implications for personality and development? In the first case, BVSR theory would lead to the expectation that creativity in highly complex domains would be strongly associated with the Openness to Experience dimension of the Big Five Personality Factors, whereas creativity in high-consensus domains would be most connected with the Conscientiousness dimension of the same Big Five Model (John, 2021). And that is essentially what has been found (Simonton, 2009b, 2021). Most notably, this personality contrast is witnessed when comparing scientific and artistic creators (Feist, 1998). Although Openness is important for both scientific and artistic creativity (given its positive correlation with cognitive disinhibition; Carson, 2014), it's more significant for the latter, whereas Conscientiousness has reverse repercussions for the two major forms of creative achievement: Creative scientists are above average, creative artists below. For instance, few activities require more Conscientiousness than learning and doing mathematics; problem sets and rigorous proofs are not for the careless and indifferent!

With respect to development, we must go back to the concept of diversifying experiences, but this time emphasize their long-term effects based on events and conditions occurring in childhood and adolescence. Specifically, with respect to that pre-career period, "highly creative individuals stem from unconventional backgrounds (e.g., cultural or religious minorities, sickly dispositions, early orphanhood, or financial trouble), had unconventional educational and training experiences (e.g., studies abroad, multiple mentors, voracious reading, and diverse hobbies), and had more conspicuous leanings toward psychopathology" (Damian & Simonton, 2014, p. 389). Yet again, the foregoing experiences are more conducive to creativity in the arts, whereas the reverse holds for creative domains at the other end of the complexity-consensus spectrum, especially the physical sciences, where both family and educational backgrounds are far more conventional and early psychopathology extremely unlikely (Damian & Simonton, 2014). Interestingly, Campbell (1960) himself suggested that multicultural experiences would enhance the capacity for BVSR creativity, a suggestion that also fits with the conjectured impact of diversifying experiences (Gocłowska, Damian, & Mor, 2018). As he put it, those "who have been thoroughly exposed to two or more cultures … seem to have the advantage in the range of hypotheses they are apt to consider, and through this means, in the frequency of creative innovation" (p. 391; see also Crisp & Turner, 2011).

Current evaluation

In truth, any creativity researcher so inclined can reject this updated BVSR outright merely by rejecting the three-criterion creativity definition. Not only may the prior knowledge of the utility be omitted, but also the utility itself may be left out, just to be on the safe side (e.g., Hills & Bird, 2019; Weisberg, 2015b). If creative ideas or responses do not have to be useful in any way, then it becomes irrelevant whether the creator has any prior knowledge of the utility, and any debate ends. Yet such a rejection would be hard to defend. The standard definition includes effectiveness as a criterion because it is really an essential attribute of creativity (Harrington, 2018; Runco & Jaeger, 2012). For example, it would be impossible to argue for creativity workshops in business or the encouragement of creativity in schools if creativity only required originality and nothing else. Originality without utility is simply too easy. Furthermore, it has already been shown earlier in this article that once utility is included as the second criterion, then the creator's prior knowledge of that utility also becomes mandatory (see also Tsao et al., 2019). Indeed, that third criterion is required not just to define creativity but also to make critical distinctions among non-creative phenomena, such as the contrast between explicit expertise and a lucky guess (Simonton, 2018b). Surely experts must *know* why a routine solution to a given problem has the highest probability (i.e., $s = puv = 1$). How can expertise be defined otherwise? Can someone who wins a fair lottery really be called an expert at lottery winning?

In addition, it should be clear by now that Campbell's (1960) BVSR has often been subject to various misconceptions that I hope this article has successfully corrected. Table 4 summarizes the four most common misconceptions and the corresponding corrections. Any residual weaknesses in Campbell's original formulation should have been removed in the current formal definitions and their implications. As an example, it must be obvious that BVSR does not deny the significance of expertise, especially not expertise in a given creative domain. Instead, BVSR deals with the consequences when a creator must go beyond that expertise to extend what they know or can do. And the only way to extend one's knowledge is to discover the limits to that knowledge, such as when well-established expectations are violated, as in problem finding. There are no short-cuts that enable the creator to bypass the need to make mistakes once reaching the edge of their expertise. As Dennett (1995) expressed it metaphorically, individuals can use "scaffolding" but not "skyhooks."

Table 4. Four common misconceptions about BVSR creativity and the corresponding corrections.

Misconception	Correction
Presupposes an analogy with Darwin's evolution by natural selection	Proto-BVSR existed before Darwin; current arguments based on epistemology, as in Campbell's original conception
Requires random variations to generate blindness	BVSR blindness requires no randomness; all random variations are blind, but so are those associated with planned systematic searches
Denies the importance of expertise	BVSR concerns how to go beyond already acquired expertise (e.g., when that expertise doesn't suffice to solve a novel problem)
Offers no implications for research	BVSR provides the basis for (a) theoretical extensions and (b) empirical investigations, including case studies of historic creativity

Note. Some other misconceptions are merely offshoots of one or more of the four listed. For example, some critics have claimed that BVSR denies the importance of intentionality in human creativity because Darwin's theory does not include that psychological concept (e.g., Sternberg, 1999). Ironically, BVSR actually requires *exceptional* intentionality – extreme persistence and determination – owing to the extra effort required. Indeed, Bain, 1855 was the first to indicate the need for "an active turn, or profuseness of energy put forth in trials of all kinds on the chance of making lucky hits" (p. 596).

If the last principle proves so fundamental, then why isn't BVSR more widely accepted? My hypothesis is that the underlying logic is broadly appreciated, but under different names. It can be easily argued that Campbell's (1960) blind-variation and selective-retention belongs to a family of expressions that attempt to convey a similar two-step principle operating during creative thought and behavior. Bain, 1855 might have been the first, but he certainly was not the only one, as indicated in Table 5. Moreover, creators themselves will often describe their own creativity in an analogous, even if more informal manner. For instance, the French poet Paul Valéry said, "It takes two to invent anything. The one makes up combinations; the other one chooses, recognizes what is important to him in the mass of things which the former has imparted to him" (Hadamard, 1945, p. 30), and Nobel laureate Linus Pauling advised a student "have lots of ideas and throw away the bad ones" (Bynum & Porter, 2006, p. 485). These various expressions all imply, even if not always explicitly, that the generation of ideas can become *decoupled* from the criteria by which those ideas are assessed (Toulmin, 1981), thereby imposing the requirement that the ideas be evaluated in a second step (see also James, 1880; cf. Kronfeldner, 2010). This second step is not required for highly sighted ideas because the high utility is ensured by the prior knowledge of that utility, knowledge that is equally responsible for the idea's high initial probability. To do otherwise would amount to irrational behavior (i.e., having $p \to 0$ even though $u \to 1$ and $v \to 1$; Simonton, 2016).

Given all the different expressions, why prefer BVSR over the others? Although it's difficult to complain about using "selective-retention" to designate the second step, Campbell's (1960) use of the term "variation" might have been ill-advised, implying the very Darwinism he was attempting to avoid. Yet the term does suggest the need for conceptual variety in the generation of possibilities to increase the chance of finding something useful (cf. "flexibility" in divergent thinking). Adding the adjective "blind" does have an advantage over the alternative expressions in which such blindness is only implicit. The concepts of "error," "verification," "test," "refutation," and "consequences" all imply that whatever the creator puts forward may prove inadequate because the utility is not known in advance. To the extent that the individual is *blind* to that utility, they must "grope in the

Table 5. *Alternative expressions for* Campbell's (1960) *BVSR in approximate historical order.*

Expression	Source(s)
trial and error	Bain, 1855; cf. "guess and check"
illumination and verification	Wallas (1926; creativity stages 3 and 4)
generate and test	Various AI algorithms (H. Simon, 1969)[1]
conjecture and refutation	Popper (1963); cf. Dennett's (1995) "Popperian creature"
unjustified variation and selective retention	Campbell (1974b); cf. Plato's concept of "justified true belief" (*Theaetetus*)
spontaneous behavior and selection by consequences	Epstein (1991) plus Skinner (1981)[2]; cf. Dennett's (1995) "Skinnerian creature"
random-generation and test versus plausible-generation and test	Boden (2004)

Note. The concepts of exploration and exploitation, though superficially similar to BVSR, do not normally represent successive stages, though they could do so (cf. March, 1991).

[1]Generate-and-test methods have been used so often and for so long that by 1969 Simon could refer to their generic application in Artificial Intelligence without giving a specific citation.

[2]Epstein was a student of Skinner's who focused on a feature of operant conditioning that his mentor largely overlooked, in route to a Generativity Theory of Creativity (Epstein, 1990, 2015). Eventually Skinner saw this first step to amount to random variation (Moxley, 1997).

dark." Hence, even Albert Einstein had to confess "Most of my intellectual offspring end up very young in the graveyard of disappointed hopes."[7] In a sense, those who dare venture into the unknown risk increasing their implicit expertise far faster than their explicit expertise.

Even so, "blind" is sometimes misperceived as an all-or-none attribute (e.g., Kronfeldner, 2010). The variations are either sighted or blind, with no intermediate values where prior knowledge lessens the degree of blindness, reducing the risk in the ventured idea or response. In fairness, I believe that this problem pinpoints a general issue, for it's difficult to identify an expression that makes explicit that there are gradations. One intriguing exception is Boden's (2004) differentiation of two forms of generation and test, namely, random-generation and plausible-generation. Obviously, the first form has zero prior knowledge (i.e., $0 \leq u \leq 1$, $v = 0$) whereas the second form has some degree of prior knowledge even if not good enough to count as perfectly sighted (i.e., $u \gg 0$, $0 \ll v \ll 1$). Yet this distinction still suggests a dichotomy, only making the split at a different spot in the prior knowledge dimension.

Until creativity researchers can agree on an alternative expression for BVSR, it's likely to stick around, especially given that so far it's the only one to boast a convenient acronym. However labeled, Campbell (1960) captured a basic truth about creativity that cannot be ignored without undermining a scientific understanding of the phenomenon. Creativity researchers who try to promote a workaround to BVSR end up introducing skyhooks that beg the question, like hypothesizing a creative process from the onset (Cziko, 1998). There's no such thing.

Looking back on the extensive history of research on BVSR, I forecast that its status will improve rather than decline. A main reason for this optimistic forecast is that several issues that interfered with its widespread acceptance have been gradually reconciled, such as the issues presented in Table 4. To offer a specific case, Simonton and Weisburg got involved in an extended and sometimes heated debate ever since Weisberg (2000) reviewed Simonton's (1999c) book-length treatment of "Darwinian perspectives on creativity," to which Simonton (2002) responded. But over time, the contrasts in their two positions have sufficiently lessened so that the common ground has become increasingly apparent (Weisberg, 2015aa; Weisberg & Hass, 2007). This gradual resolution of differences should continue with respect to other BVSR opponents once it's realized that the theory has evolved considerably over the years.

Conclusion

Campbell's (1960) original article was published in the days when the American Psychological Association (APA) did not require abstracts, even for a journal featuring the status of *Psychological Review* (see also Mednick, 1962). Longer closing summaries were used instead. Evidently, APA has been trying to remedy that omission retroactively, for 56 years later some anonymous writer got around to composing an abstract for APA's online resources. It reads,

> How does man know anything and, in particular, how can we account for creative thought? Campbell posits 2 major conditions: mechanisms which produce wide and frequent variation (an inductive, trial and error, fluency of ideas) and criteria for the selection of the inductive given (the critical function). The ramifications of this perspective are explored in terms of organic evolution and human history, and in terms of psychology and epistemology. This exposition is offered as a pretheoretical model. (PsycINFO Database Record (c) 2016 APA, all rights reserved)

Unfortunately, whoever wrote this summary got a lot plain wrong, as anyone can confirm simply by reading Campbell's actual essay, or even just its summary. Much of the abstract's contents seem to reflect views that accrued long after the article's publication. That said, one point in the abstract is absolutely correct: By today's standards, the 1960 exposition only represents a "pretheoretical model." Indeed, a former editor of *Psychological Review* once confided to me that this piece would not be accepted for publication in that journal today. It is hoped that the current BVSR update is no longer pretheoretical.

Notes

1. A distinction must be made between Mednick's associative theory and the specific instrument that he incorrectly thought instantiated that theory, for the Remote Associates Test's psychometric properties cause it to load heavily on convergent thinking (Lee, Huggins, & Therriault, 2014). The test should have been open-ended, with no pre-determined correct answers – like asking participants to generate their own remote associates.
2. Past formal treatments have added subscripts to certain parameters in order to index the variations (i.e., i = 1, 2, 3 . . . k) and, where appropriate, trial order (i.e., t = 1, 2, 3, . . . n; e.g., Simonton, 2013a, 2013b). Alternatively, select parameters may have "prior" and "post" subscripts as in Bayesian analyses (Tsao et al., 2019). However, these subscripts are not necessary for the demonstrations carried out here. The logic is so straightforward.
3. Simonton (2013b) defined blindness as the inverse of sightedness (i.e., $b = 1 - s$), while Tsao et al. (2019) separated out blindness from surprise via probabilistic analysis. Finally, Simonton's (2011a) initial attempt to define a blind-sighted continuum using the coefficient of congruence (Tucker's phi) proved inadequate in handling some special cases.
4. An anonymous reviewer asked why Dietrich and Haider (2015) were not included on this list. Unfortunately, these authors adopted Kronfeldner's (2010) position that BVSR was invalid because blindness was a discrete all-or-none attribute of variations, doing so without awareness of Simonton's (2010a, 2011a, 2013b) contrary demonstration that blindness can indeed be a continuous variable. That said, because Dietrich and Haider treat the partial sightedness of creativity, their discussion of the brain mechanisms underlying the variation-selection process can easily be transposed into a BVSR theory. Some indications in their article even suggest an openness to that possibility.
5. Here the focus is on BVSR's implications for empirical research on creativity, not BVSR's implications for research in general. Not surprisingly, given Campbell's methodological contributions to program evaluation, his epistemological theories also have repercussions for evaluation research (Picciotto, 2019).
6. In such inquires, care must be taken to rely on actual archival sources rather than the retrospective reports of the creator's themselves, for sometimes the latter are given to various distortions for dramatic effect. A notorious example is Samuel Taylor Coleridge's claim that his *Kubla Khan* was composed in its entirety during an opium-induced reverie, when surviving evidence shows that his origin story is far from true (Schneider, 1953). In contrast, Elizabeth Bishop left behind more than a dozen heavily marked-up drafts for her *One Art* (a personal favorite of this article's author). Over the course of creating a 19-line masterpiece, words, phrases, and whole lines come and go, meanings and images subtly change, and even the poetic form undergoes a surprising transformation (Garner & Sehgal, 2021). Pure BVSR.
7. Quoted in http://www.aps.org/publications/apsnews/200512/history.cfm.

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ERRATA

Some printer's errors failed to get corrected even after my explicit request. Most notably, "Bain, 1855" was supposed to be "Bain (1855)" as consistent with APA and CRJ citation format. This mistake occurs 5 times throughout the article.

Another oddity is that "Weisberg, 2015a" was changed to "Weisberg, 2015aa"

Page numbers will be provided once the article becomes in print.

Another error belongs to the author rather than the printer, and the error is conceptual. The Geneplore model of Finke, Ward, and Smith (1992) was placed in Table 3 as a creative process or procedure when it more properly belongs in Table 5 in a new row before Boden's (2004). Then the portmanteau Geneplore would be resolved back into "generation and exploration," where the first step entails the production of "preinventive structures" and the second step the evaluation of those structures to determine which ones are truly inventive (i.e., possess utility). In short, Geneplore logically constitutes a special case of BVSR. That also means that the experimental research that the authors conducted on their model can equally count as research on BVSR. It's worth pointing out, apropos of Table 3, that the three authors favored three different cognitive mechanisms behind Geneplore: forgetting fixation (Smith), structured imagination (Ward), and visual synthesis (Finke)(Smith, personal communication, 2022). Hence, like BVSR generally, it's not a homogeneous process or procedure.