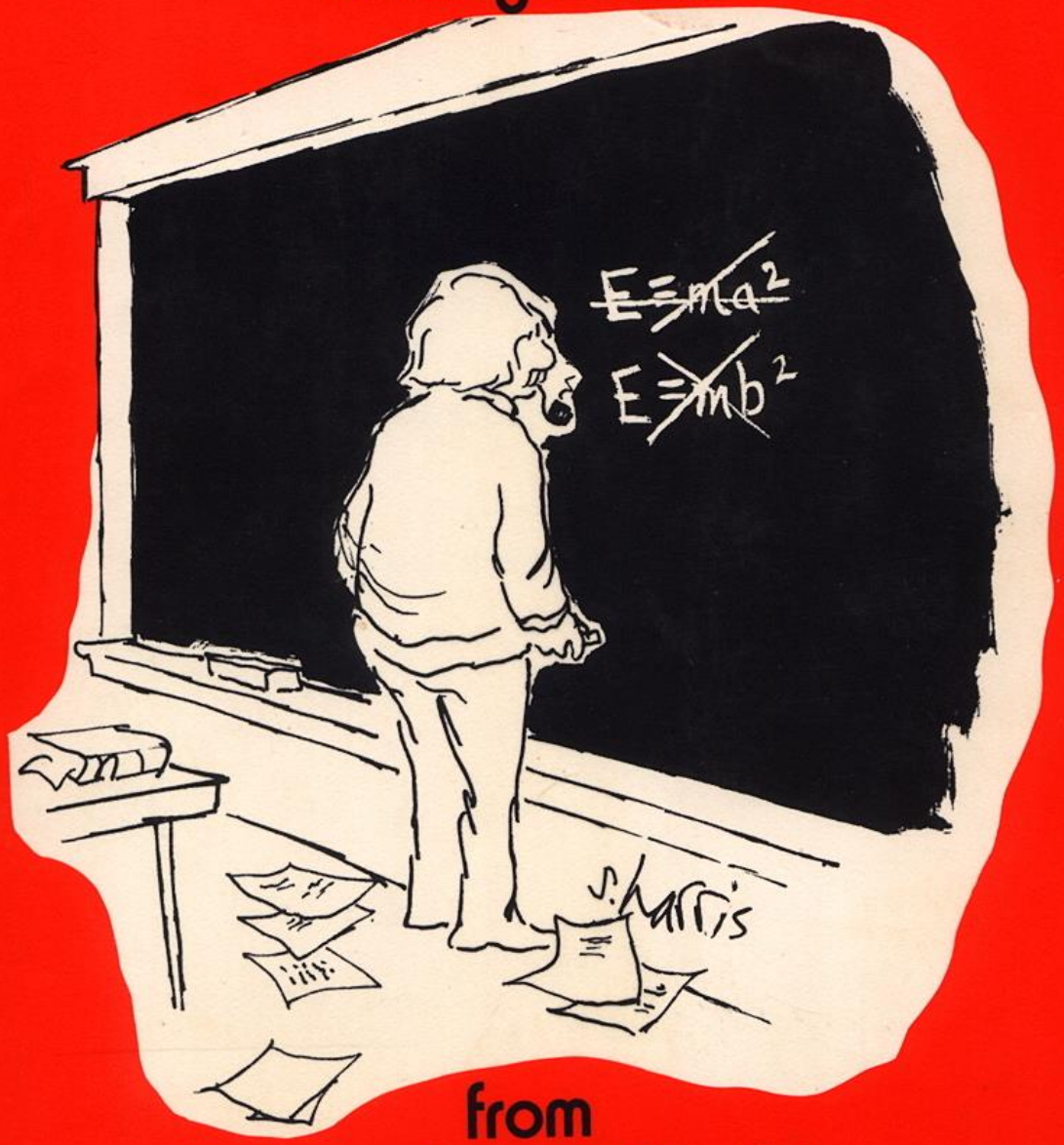
cartoons by

Sidney Harris



from

American Scientist

Scientific Creativity as *Blind* Variation

Campbell (1960) After the Half-Century Mark

Background

- Donald T. Campbell
  - (1960): “Blind variation and selective retention in creative thought as in other knowledge processes” (*Psychological Review*)
  - BVSR: blind “thought trials” subjected to
    - Simultaneous or Sequential Selection
    - External or Internal Selection
  - Blindness versus Sightedness

Sightedness versus blindness

- Let there be two ideational variants X and Y with probabilities p (X) > 0 and p (Y) > 0
- let their fitness values be w (X) and w (Y), which we also take as probabilities;
- then the variants are *sighted* if, say,
  - p (X) > p (Y) and w (X) > w (Y), *plus*
  - w (X) > w (Y) → p (X) > p (Y)
- i.e., variant probabilities and fitness values are “coupled” (Toulmin, 1972)

Sightedness versus blindness

- But if p (X) ≈ p (Y) although w (X) ≠ w (Y);
- or if p (X) > p (Y) although w (X) < w (Y);
- then the variants are *blind*
- i.e., variant probabilities and fitness values are “decoupled”
- Two simple examples:
  - Fork in the road dilemma
  - The two-strings problem

Sightedness versus blindness

- N.B.:
  - If *w* (X) > *w* (Y) and *p* (X) > *p* (Y)
- but
  - *w* (X) > *w* (Y) does ***not imply*** *p* (X) > *p* (Y)
- then decoupling or blindness still applies
- e.g., the “lucky guess”

Blind-Sighted Continuum

- Quantitative rather than qualitative trait
- Two sources
  - *Imperfect pre-selection*:
    - admission of false positives: $p(Z) > 0$ but $w(Z) = 0$
    - omission of false negatives: $p(Z) = 0$ but $w(Z) > 0$

Blind-Sighted Continuum

- Quantitative rather than qualitative trait
- Two sources
  - *Imperfect pre-selection*
  - *Partial coupling*: surviving variants may vary in degree of decoupling:
    - e.g., *w* (X) = 1 and *w* (Y) = 0 leads to the weak expectation or "hunch" that *p* (X) > *p* (Y) but not that *p* (X) = 1 and *p* (Y) = 0
- Although theoretically orthogonal, the two sources probably correlated

Identification

- How does one determine whether a process generates blind variations?
  - Case 1: The variations are *explicitly* blind
    - i.e., the BV mechanism is so designed *a priori*
  - Case 2: The variations are *implicitly* blind
    - The variations themselves have the immediate properties of blindness
    - The underlying variation processes have the qualities that would be expected to yield blindness

Case 1: Explicit Blindness

- Combinatorial operations
  - Systematic
    - Search scans and grids
      - e.g., radar, where
      - for all $0 \leq \theta_t \leq 2\pi$
      - all $p(\theta_t)$ are exactly equal
      - yet not all $w(\theta_t)$ are equal

Case 1: Explicit Blindness

- Combinatorial operations
  - Systematic
    - Search scans and grids
    - Inductive discovery programs: e.g. …

Case 1: Explicit Blindness

- BACON's discovery of Kepler's Third Law $P^2 = kD^3$ or $P^2/D^3 = k$
  - Three heuristics reduce the search by half,
  - skipping $P^2/D = k$ and $P^2/D^2 = k$ in route to
  - $P/D = k$, $P/D^2 = k$, and, finally, $P^2/D^3 = k$,
  - with corresponding fitness values
  - $w\ (P/D) = 0$, $w\ (P/D^2) = 0$, and $w\ (P^2/D^3) = 1$
  - yielding some degree of decoupling

Case 1: Explicit Blindness

- Combinatorial operations
  - Systematic
  - Stochastic
    - Evolutionary algorithms (genetic algorithms, evolutionary programming, genetic programing)
    - Probably all programs that simulate creativity:
      - “a convincing computer model of creativity would need some capacity for making random associations and/or transformations … using random numbers” (Boden, 2004, p. 226)

Case 2: Implicit Blindness

- Variations with properties of blindness
  - Superfluity (too many diverse, even incommensurate variants)
    - “the world little knows how many of the 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”
      – Michael Faraday

Case 2: Implicit Blindness

- Variations with properties of blindness
  - Superfluity
    - Precaution:
      - Although superfluity implies BV,
      - the absence of superfluity does not imply not-BV

Case 2: Implicit Blindness

- Variations with properties of blindness
  - Superfluity
  - Backtracking (too many rejected variants; absence of asymptotic honing): e.g.,

“I only succeeded in solving such problems after many devious ways, by the gradually increasing generalisation of favourable examples, and by a series of fortunate guesses. I had to compare myself with an Alpine climber, who, not knowing the way, ascends slowly and with toil, and is often compelled to retrace his steps because his progress is stopped; sometimes by reasoning, and sometimes by accident, he hits upon traces of a fresh path, which again leads him a little further; and finally, when he has reached the goal, he finds to his annoyance a royal road on which he might have ridden up if he had been clever enough to find the right starting-point at the outset. In my memoirs I have, of course, not given the reader an account of my wanderings, but I have described the beaten path on which he can now reach the summit without trouble.”

- Hermann von Helmholtz

Case 2: Implicit Blindness

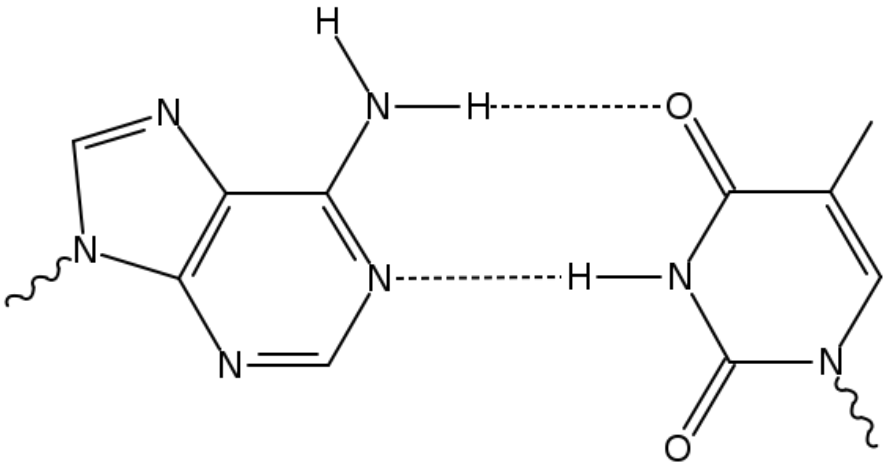
- Processes that should yield blindness
  - Associative richness:
    - remote associations (Mednick)
    - unusual associations (Gough)
    - divergent thinking (e.g., unusual uses; Guilford)
    - primary process/primordial cognition (Kris/Martindale)
    - allusive/over-inclusive thinking (Eysenck et al.)
    - Janusian and homospatial imagery (Rothenberg)
    - clang associations (Galton)
  - all supporting or stimulating “spreading activation” decoupled from outcome fitness
  - doing so both individually and collectively

Case 2: Implicit Blindness

- Processes that should yield blindness
  - Associative richness
  - Defocused attention (e.g., reduced latent inhibition & negative priming):
    - enhanced “opportunistic assimilation”
    - reduced “functional fixedness”
    - enhanced susceptibility to “pseudo serendipity”

Case 2: Implicit Blindness

- Processes that should yield blindness
  - Associative richness
  - Defocused attention
  - Behavioral/Cognitive “tinkering”
    - e.g., James Watson’s cardboard molecular models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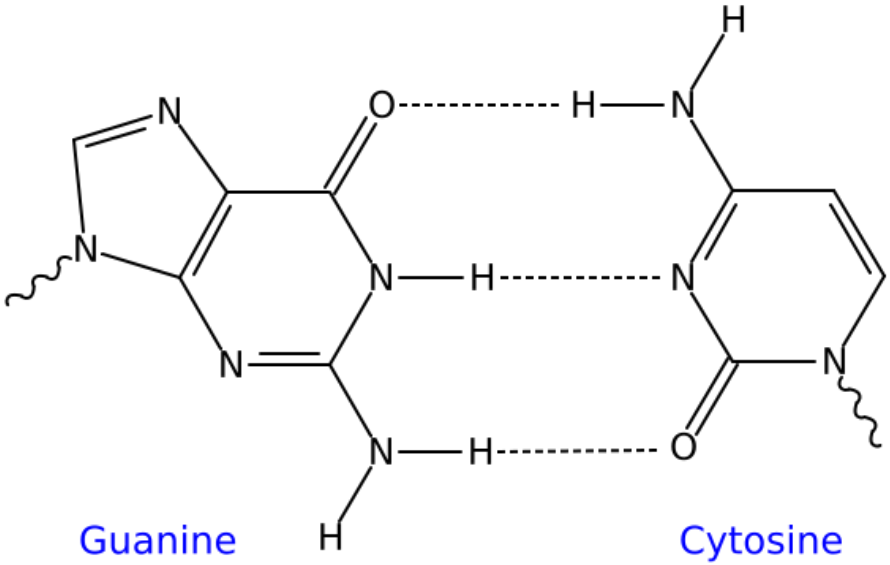
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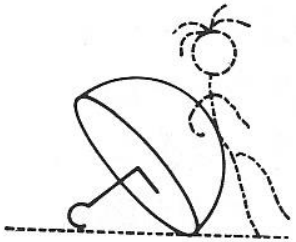
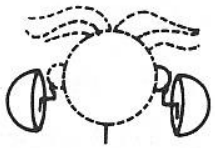
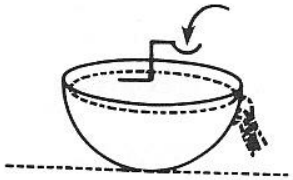
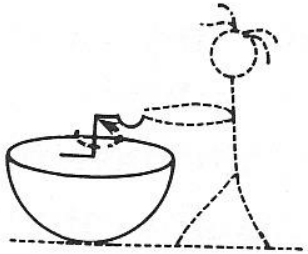
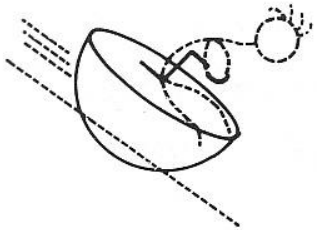
    - cf. Geneplore model (Finke, Ward, & Smith, 1992)

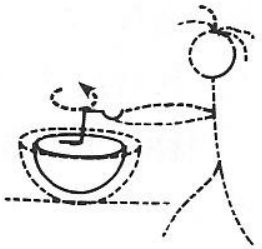


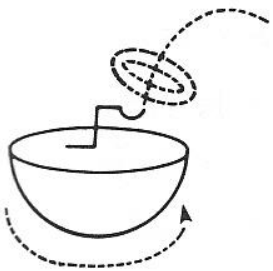












Case 2: Implicit Blindness

- Processes that should yield blindness
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  - Defocused attention
  - Behavioral/Cognitive “tinkering”
    - e.g., James Watson’s molecular models
    - e.g., Albert Einstein’s “combinatorial play”
    - cf. Geneplore model (Finke, Ward, & Smith, 1992)
  - Heuristic search

Heuristic Search

- *Algorithmic methods*: perfect coupling
- *Heuristic methods*: means-end analysis, hill climbing (steepest ascent), working backwards, analogy, trial-and-error, etc.
- Continuum from *well-defined* to *ill-defined* problem spaces: progression from “strong” to “weak” methods; increased decoupling
- *Trial-and-error meta-heuristic*: generate and test all heuristics until solution obtains

Misconceptions

- BVSR denies creative purpose
- BVSR denies domain expertise
- BVSR requires ideational randomness
- BVSR requires an isomorphic analogy

Contributions

- Exploratory: Generative Metaphor
  - Inspired and continues to inspire original research on creativity and discovery
    - e.g. disciplinary hierarchies and their relation to dispositional traits and developmental experiences of scientists in different disciplines

Contributions

- Exploratory: Generative Metaphor
  - Inspired and continues to inspire original research on creativity
- Explanatory: Inclusive Framework
  - Provides overarching theory that can encompass a diversity of models, including …
- Predictive: Combinatorial Models
  - e.g., creative productivity & multiple discovery

“If we knew what we were doing it wouldn't be research.”

- Albert Einstein