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Creativity in Scientific and Engineering Research (aka Implausible Utility and Informed Contrariness)

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1. Why Should (or Shouldn't) We Care? 5m
2. The New Take 40m
3. Implications and What's Incomplete/Next 10m

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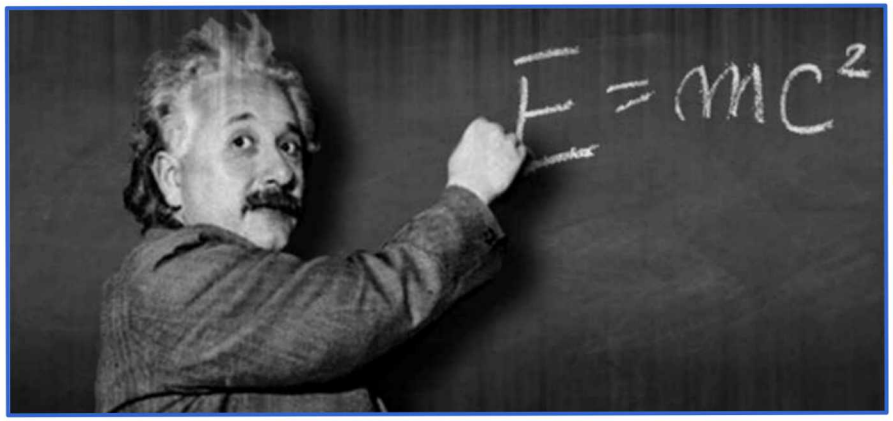
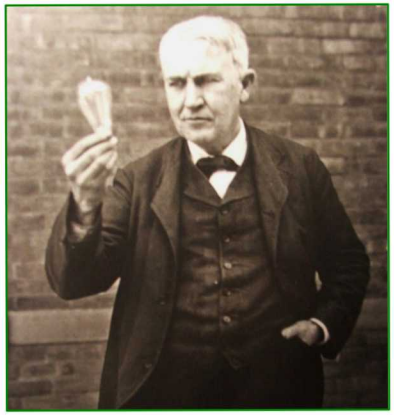
Why Should (or Shouldn't) We Care?

Science



Technology

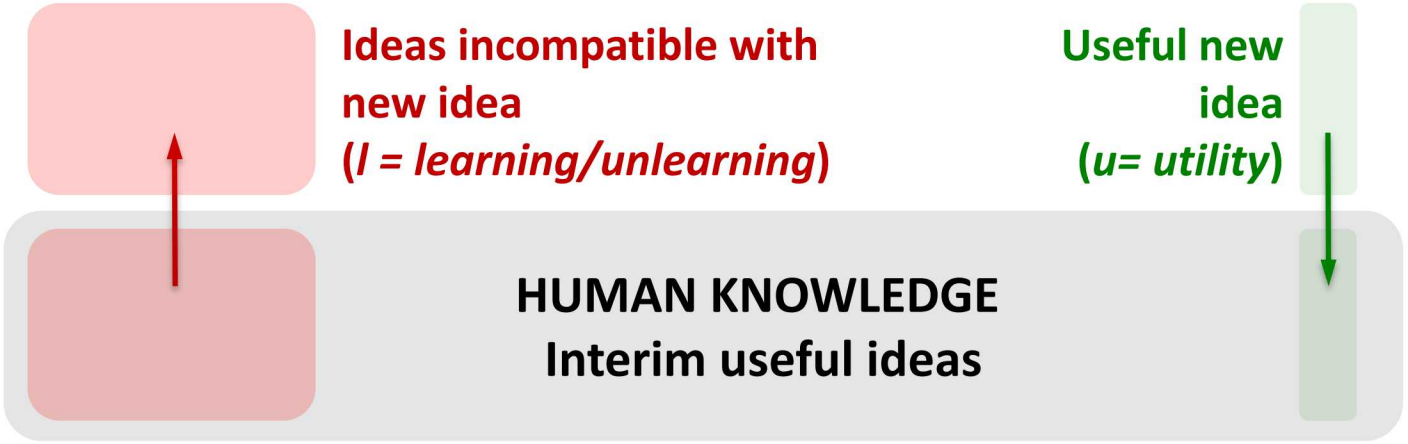


Culture

- **<u>Why we should</u>:**
  Creativity is associated with the greatest advances in human knowledge, how could we not care
- **<u>Why we shouldn't</u>:**
  Creativity is too difficult a topic, better just "to do" and not overanalyze the "doing"
  I don't buy this: we can learn from organizations that have successfully fostered creativity in S&T, and from creativity in artificial intelligence

Our Ansatz:

Creative Outcome = *Significant* Advance in Human Knowledge

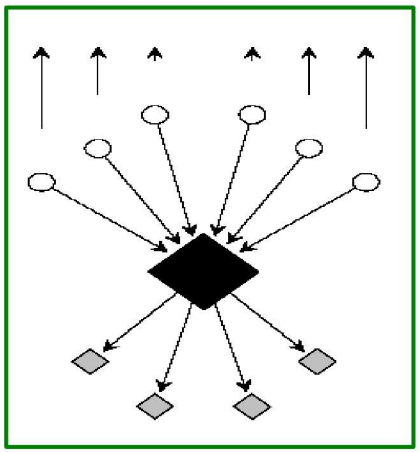


What gets us into trouble isn't what we don't know.
It's what we know for sure that just ain't so.
– (not) Mark Twain

The idea of “creative destruction” isn’t new

Gestaltists	1900’s	Psychology	Gestalt Shift
Joseph Schumpeter	1940’s	Economics	Creative Destruction
Thomas Kuhn	1960’s	History of Science	Paradigm Shift
Clay Christensen	1990’s	Business	Disruptive Innovation
Laurent Itti & Pierre Baldi	2000’s	Psychology	Surprise and Human Learning
Russell Funk	2010’s	Bibliometrics	Citation Annihilation

Moritz Koster, Miriam Langeloh and Stefanie Hoehl, “Visually entrained theta oscillations increase for unexpected events in the infant brain,” Psychological Science 1-8 (2019).



Russel Funk, Jason Owen-Smith, “A dynamic network measure of technological change,” Management Science 63, 791-817 (2017).

How to combine *utility* and *learning*?

Dean Simonton's
"Eightfold typology of creativity and uncreativity"
Ansatz

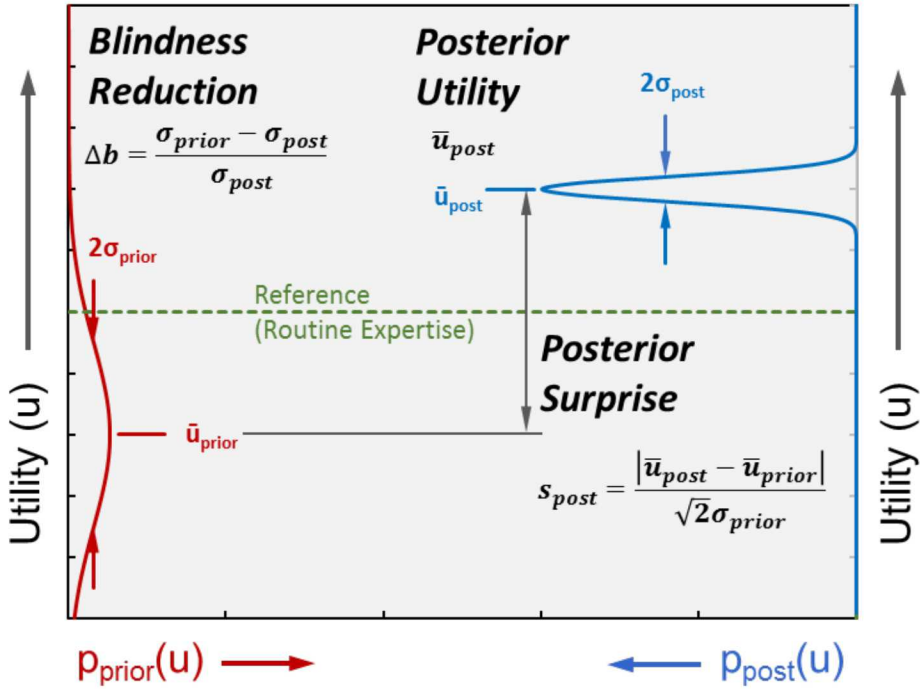
$$c = u \cdot \underbrace{(1-p)}_{\text{Novelty}} \cdot \underbrace{(1-v)}_{\text{Blindness}} = u \cdot l$$

Useful Learning

"Leading indicators" of learning

Quantifying *learning*

Kullback–Leibler (KL) divergence over prior and posterior assessments of utility



$$l = D_{KL}(p_{post}, p_{prior})$$

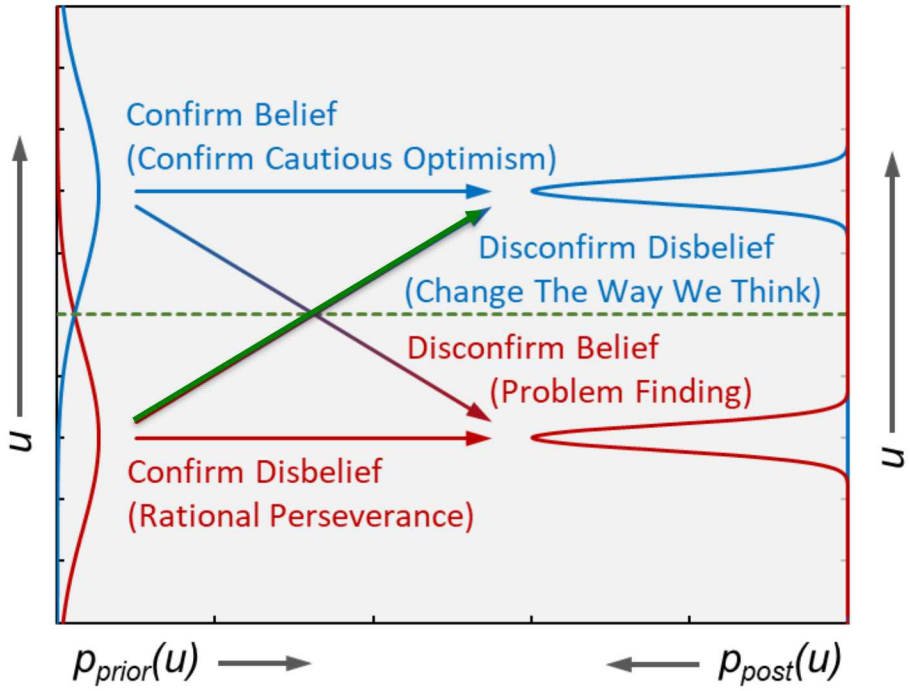
$$= \int_{-\infty}^{+\infty} p_{post}(u)\, ln\left(\frac{p_{post}(u)}{p_{prior}(u)}\right) du$$

$$= ln(1+\Delta b) - \frac{1}{2} + \frac{1}{2(1+\Delta b^2)} + s_{post}^2$$

$$\sim s_{post}^2$$

= Implausibility^2

Creative and uncreative outcome: fourfold typology



Creative Outcome = ***Useful Learning*** $= \bar{u}_{post} \cdot l \sim \bar{u}_{post} \cdot s^2_{post} =$ ***Implausible Utility***

Implications on creative process:

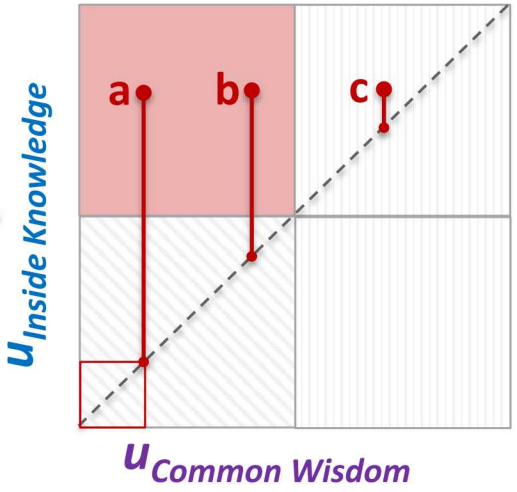
how *not* to choose scientific & engineering research ideas

Informed Contrariness = Research Arbitrage

$= u_{Inside\ Knowledge} - u_{Common\ Wisdom}$

People
Tools and Data
1st Principles Insights

← Maximize Inside Knowledge (Unfair Advantage)



↓ *Maximize Contrariness*

Unlikely Solution (Special Relativity)
Unlikely Problem (the Laser)

Tell me something that's true that almost nobody agrees with
-- Peter Thiel