Make everything as simple as possible, but not simpler.

attributed to Albert Einstein

Psychological AI:
Simplicity and Transparency in Prediction

Gerd Gigerenzer

HARDING CENTER FOR RISK LITERACY

Max Planck Institute for Human Development

RISK VS UNCERTAINTY

RISK:

You know all possible future states of the world, their consequences and probabilities.

➔ FINE-TUNED OPTIMIZATION POLICIES
(e.g. expected utility models, Bayesian probability updating)

UNCERTAINTY:

You cannot know all possible future states, their consequences and probabilities.

➔ ROBUST HEURISTICS
(e.g. satisficing, fast-and-frugal trees, social heuristics)

Knight 1921, *Risk, Uncertainty and Profit,* Houghton Mifflin.

Gigerenzer & Selten (Eds.) 2001, *Bounded Rationality: The Adaptive Toolbox,* MIT Press.

HOW TO CATCH A FLYBALL

CALCULATE TRAJECTORY:

$$z(x) = x\left(\tan\alpha_0 + \frac{mg}{\beta v_0 \cos\alpha_0}\right) + \frac{m^2 g}{\beta^2}\ln\left(1 - \frac{\beta}{m}\frac{x}{v_0\cos\alpha_0}\right)$$

HOW TO CATCH A FLYBALL

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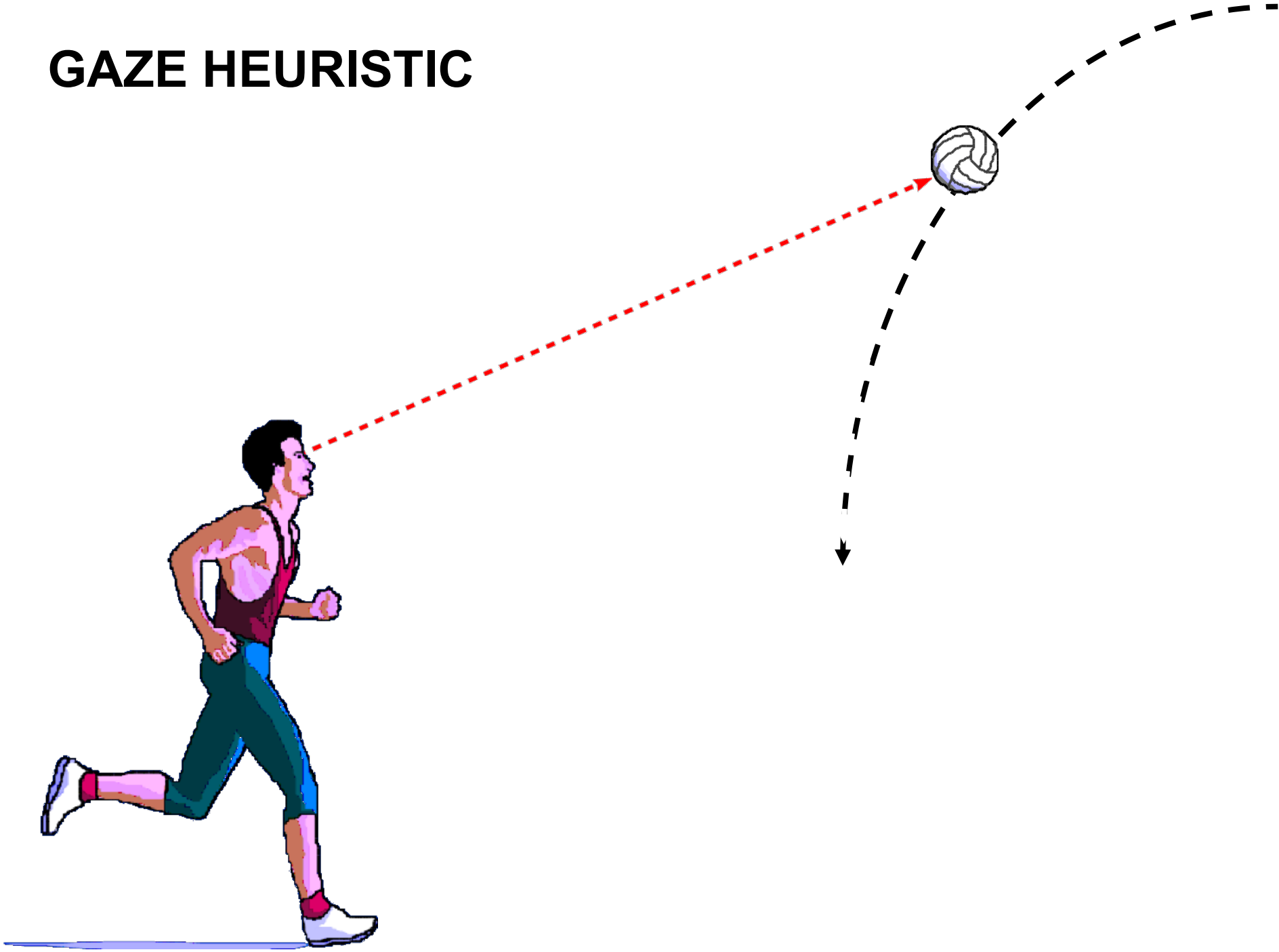
$$z(x) = x\left(\tan\alpha_0 + \frac{mg}{\beta v_0 \cos\alpha_0}\right) + \frac{m^2 g}{\beta^2}\ln\left(1 - \frac{\beta}{m}\frac{x}{v_0\cos\alpha_0}\right)$$

USE GAZE HEURISTIC:

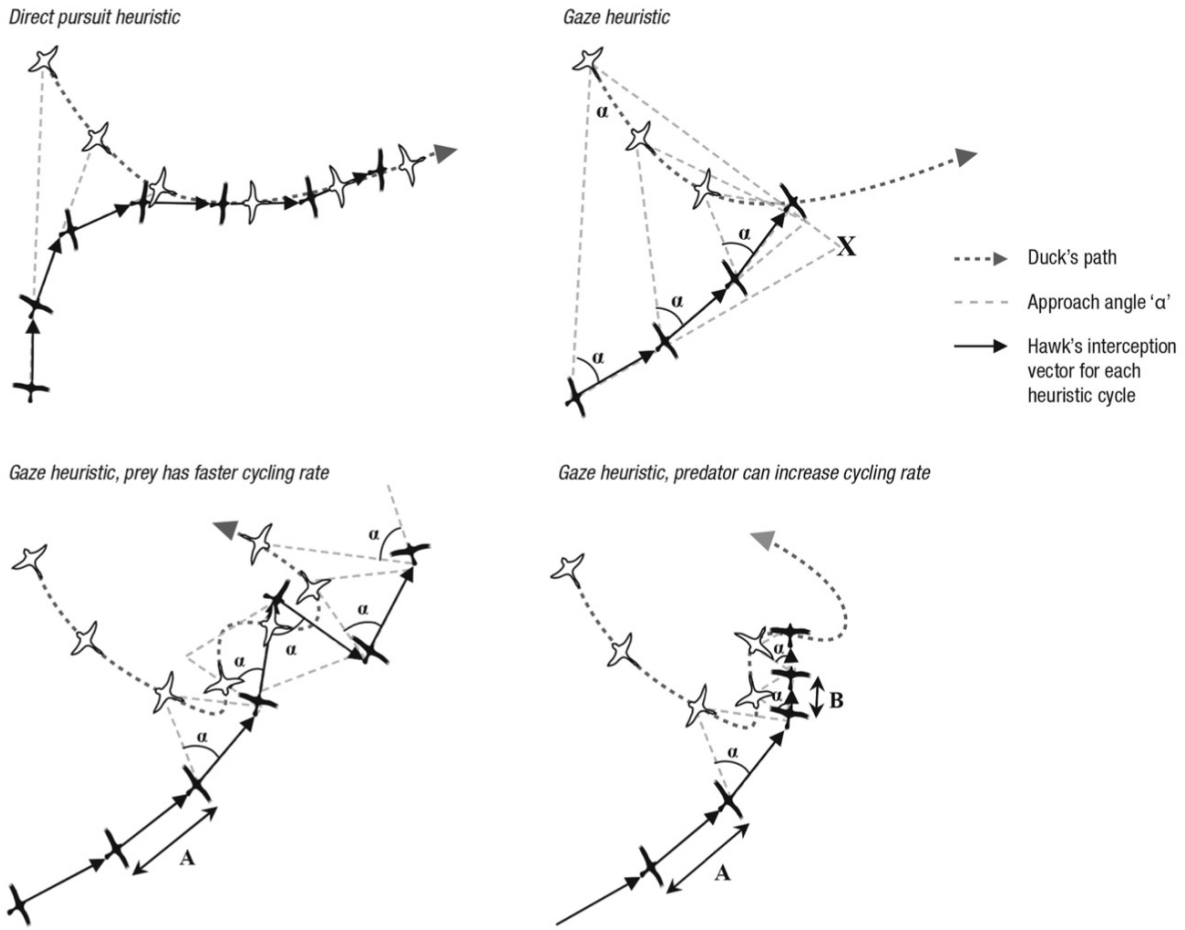
1. Fix your gaze on the ball,
2. start running, and
3. adjust your running speed so that the angle of gaze remains constant.

Gigerenzer G. (2007). *Gut feelings: The intelligence of the unconscious.* Penguin Books

GAZE HEURISTIC



Predators Pursuing Prey



Hamlin 2017. *Topics in Cognitive Sciences*

“THE MIRACLE ON THE HUDSON RIVER”

US Airways Flight 1549

January 15, 2009

PSYCHOLOGICAL AI: *To use human heuristics to make computers smart. Herbert Simon's original meaning of AI, where "I" refers to human intelligence.*

TAKE HEURISTICS SERIOUSLY: *In situations of uncertainty (as opposed to risk), simple heuristics can outperform complex strategies. (Don't be misled by the System 1/ System 2 story.)*

TAKE UNCERTAINTY SERIOUSLY: *Complex models likely predict well in stable situations, while simple models are likely to predict well in uncertain, dynamic situations. Methodology: out-of-population prediction, not just out-of-sample.*

TRANSPARENCY AND SIMPLICITY: *Be aware of non-transparent models that cannot be scrutinized by scientific method. Simplicity enables transparency.*

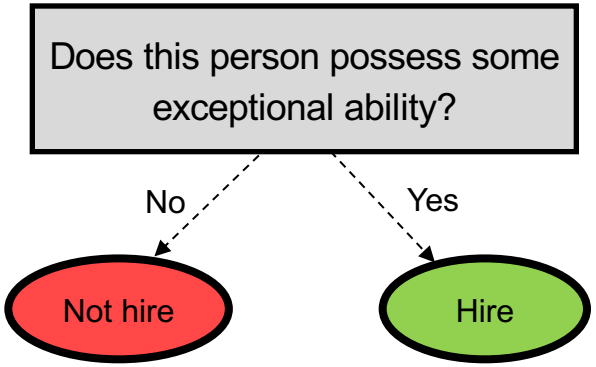
Gigerenzer, Hertwig & Pachur (2011). *Heuristics: The Foundations of Adaptive Behavior.* London: Penguin

Green & Armstrong (2015). *Journal of Business Research.*

Katsikopoulos, Simsek, Buckmann, & Gigerenzer (2020). *Classification in the Wild*. MIT Press

Makridakis, Spiliotis & Assimakopoulos (2020). *International Journal of Forecasting*.

Hiring:
One-Reason Heuristic

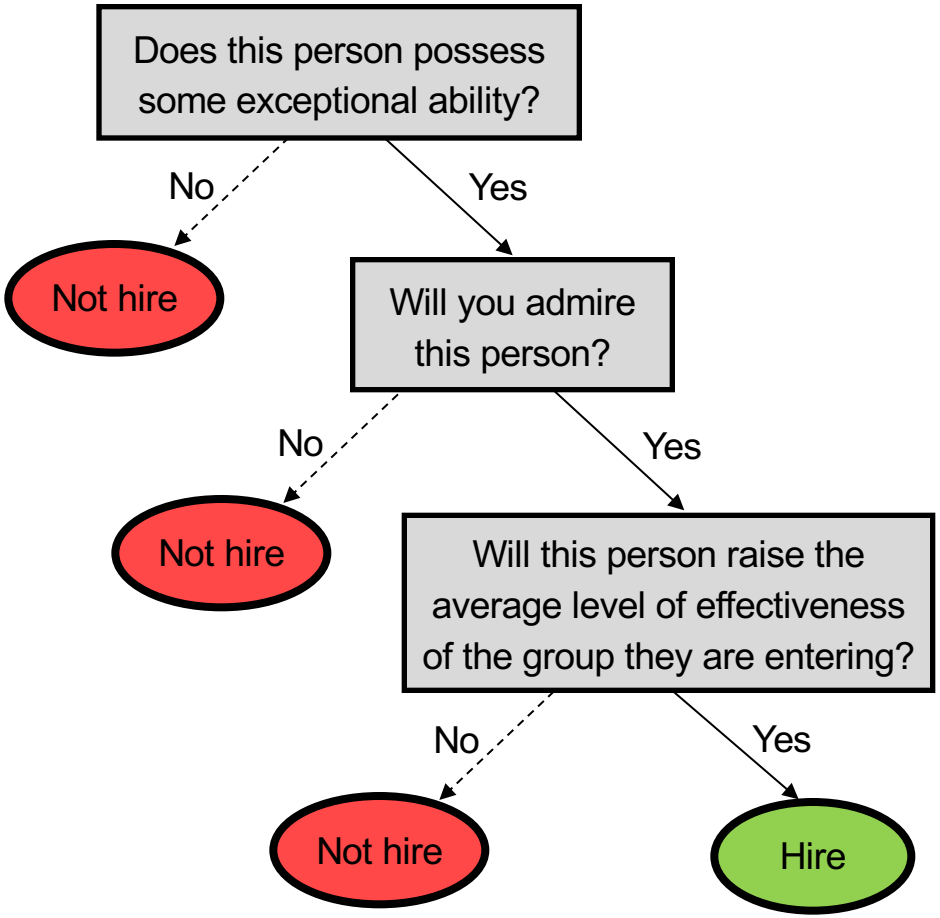


Tesla CEO Elon Musk

"Tell me about some of the most difficult problems you worked on and how you solved them."

Popomaronis T. 2021. Elon Musk asks this question at every interview to spot a liar–why science says it actually works. CNBC
Gigerenzer, Reb & Luan (in press). *Annual Review of Organizational Psychology and Organizational Behavior, 9*.

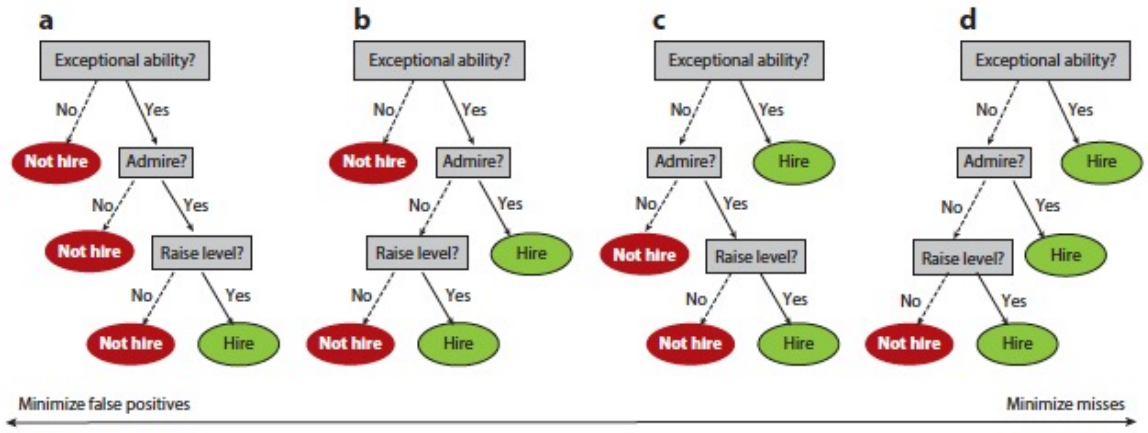
Hiring:
Fast-and-Frugal Tree



Amazon CEO Jeff Bezos

Popomaronis T. 2020. Jeff Bezos's 3-question rule for hiring new Amazon employees-and how to answer them right. CNBC
Gigerenzer, Reb & Luan (in press). *Annual Review of Organizational Psychology and Organizational Behavior, 9*.

Design of Fast-and-Frugal Trees



Jeff Bezos

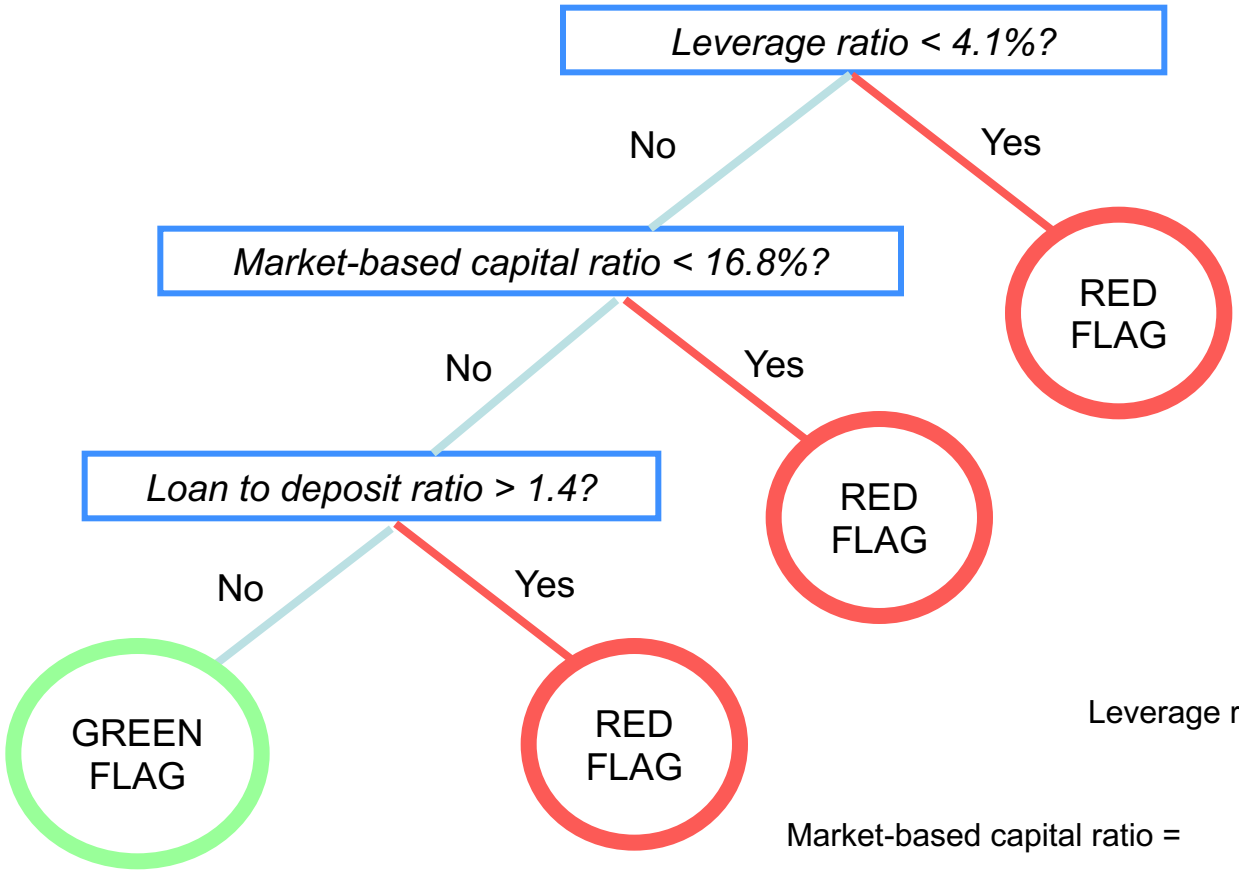
Gigerenzer, Reb & Luan (in press). *Annual Review of Organizational Psychology and Organizational Behavior, 9*.

THE BANK OF ENGLAND & MAX PLANCK INSTITUTE PROGRAM: "Simple heuristics for a safer world of finance"

Haldane, A. G. "The Dog and the Frisbee". Federal Reserve Bank Economic Policy Symposium, Jackson Hole 2012.
www.bankofengland.co.uk

Aikman, Galesic, Gigerenzer, Kapadia, Katsikopoulos, Kothiyal, Murphy & Neumann (in press).
Industrial and Corporate Change

FAST-AND-FRUGAL TREE FOR ASSESSING BANK VULNERABILITY



$$\text{Leverage ratio} = \frac{\text{Tier 1 capital}}{\text{Total assets}} * 100$$

$$\text{Market-based capital ratio} = \frac{\text{Market capitalization}}{\text{Risk-weighted assets}} * 100$$

$$\text{Loan to deposit ratio} = \frac{\text{Retail loans}}{\text{Retail deposits}}$$

Aikman, Galesic, Gigerenzer, Kapadia, Katsikopoulos, Kothiyal, Murphy & Neumann (2021).
Industrial and Corporate Change

Heuristics and Big Data Analytics

Out-of-Population Prediction

How to Forecast the Spread of the Flu?

Google Flu Trends (Big data analytics): *secret algorithm*

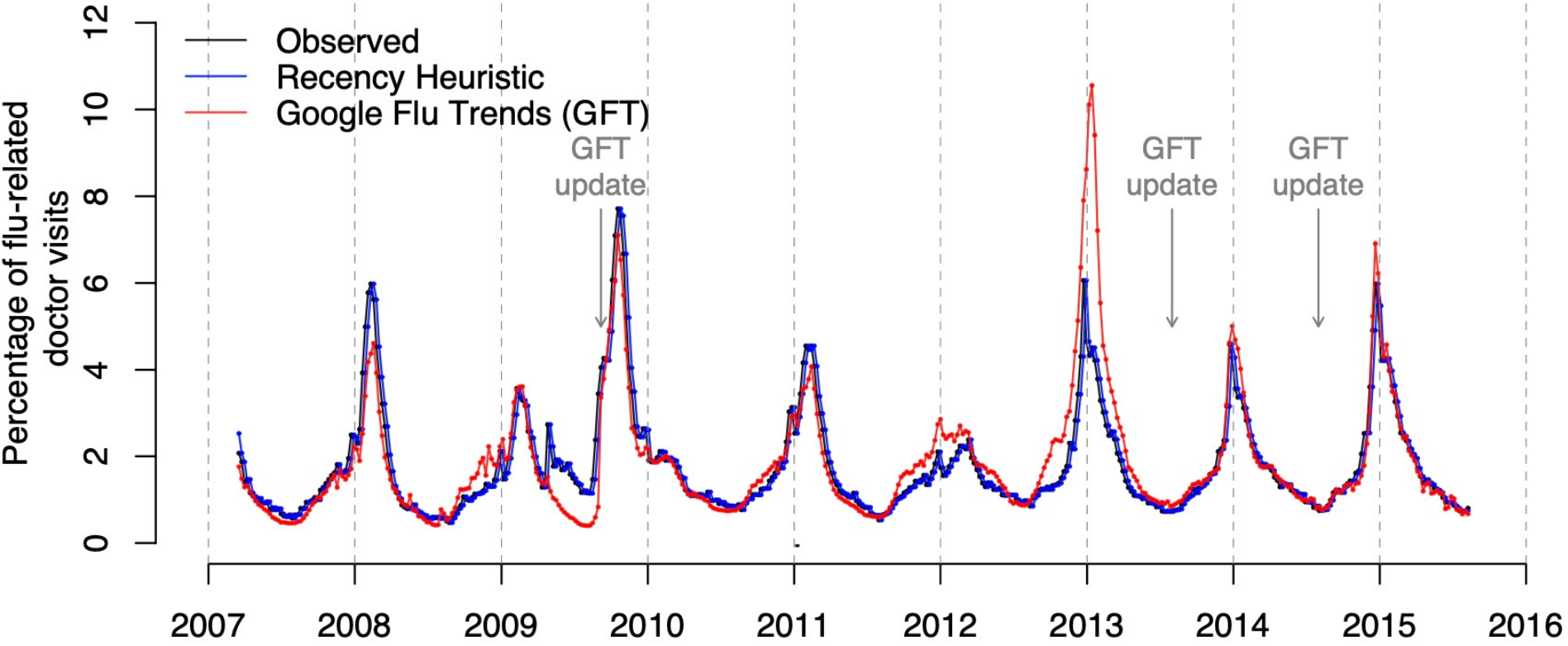
Based on an analysis of some 50 million search terms, trained on data from 2003 to 2007, and tested on data from 2007 to 2008. The first version used 45 variables; when it failed to predict the outbreak of the swine flu, it was made more complex by using 160 variables.

Recency Heuristic (One data point): *Predict that this week's proportion of flu-related doctor visits equals the proportion of the most recent past week.*

Based on psychological analysis, dating back to Brown's (1838) *law of recency.*

Katsikopoulos, Simsek, Buckmann, & Gigerenzer (in press). *International Journal of Forecasting*.
Lazer, Kennedy, King, & Vespignani (2014). *Science*.

One Data Point Predicts the Flu Better Than Big Data



Mean absolute error (in percentage points):

Recency Heuristic	**0.20**
Google Flu Trends	**0.38**

Katsikopoulos, K., Simsek, O., Buckmann, M., & Gigerenzer, G. (in press). *International Journal of Forecasting*.

Economic Inquiry

WEAI

RATIONAL HEURISTICS? EXPECTATIONS AND BEHAVIORS IN EVOLVING ECONOMIES WITH HETEROGENEOUS INTERACTING AGENTS

GIOVANNI DOSI, MAURO NAPOLETANO, ANDREA ROVENTINI, JOSEPH E. STIGLITZ and TANIA TREIBICH*

We analyze the individual and macroeconomic impacts of heterogeneous expectations and action rules within an agent-based model populated by heterogeneous, interacting firms. Agents have to cope with a complex evolving economy *characterized by deep uncertainty resulting from technical change, imperfect information, coordination hurdles, and structural breaks. In these circumstances, we find that neither individual nor macroeconomic dynamics improve when agents replace myopic expectations with less naïve learning rules. Our results suggest that fast and frugal robust heuristics may* not *be a second-best option but rather "rational" responses in complex and changing macroeconomic environments.* (*JEL* C63, D8, E32, E6, O4)

Predicting Customer Purchases

Out-of-Population Prediction

Pareto/ Negative Binomial Distribution Model:

Purchases: Poisson distribution with purchase parameter λ.
Customer life times: Exponential distribution with dropout rate parameter μ.
Across customers: purchase and dropout rates follow a gamma distribution.

$$P(\tau > T | r, s, \alpha < \beta, X = x, t, T) =$$
$$\left[1 + \frac{s}{a}\left[\left(\frac{\alpha + T}{\beta + t}\right)^{r+x} F\left(a, r + x; a + 1, \frac{\beta - \alpha}{\beta + t}\right)\left(\frac{\beta + T}{\beta + t}\right)^{s} - \left(\frac{\alpha + T}{\beta + T}\right)^{r+x} F\left(a, r + x; a + 1, \frac{\beta - \alpha}{\beta + T}\right)\right]\right]^{-1}$$

where $a = r + x + s$ and $F(\cdot)$ denotes the hypergeometric function.

Wübben, M., & Wangenheim, F. (2008). *Journal of Marketing*

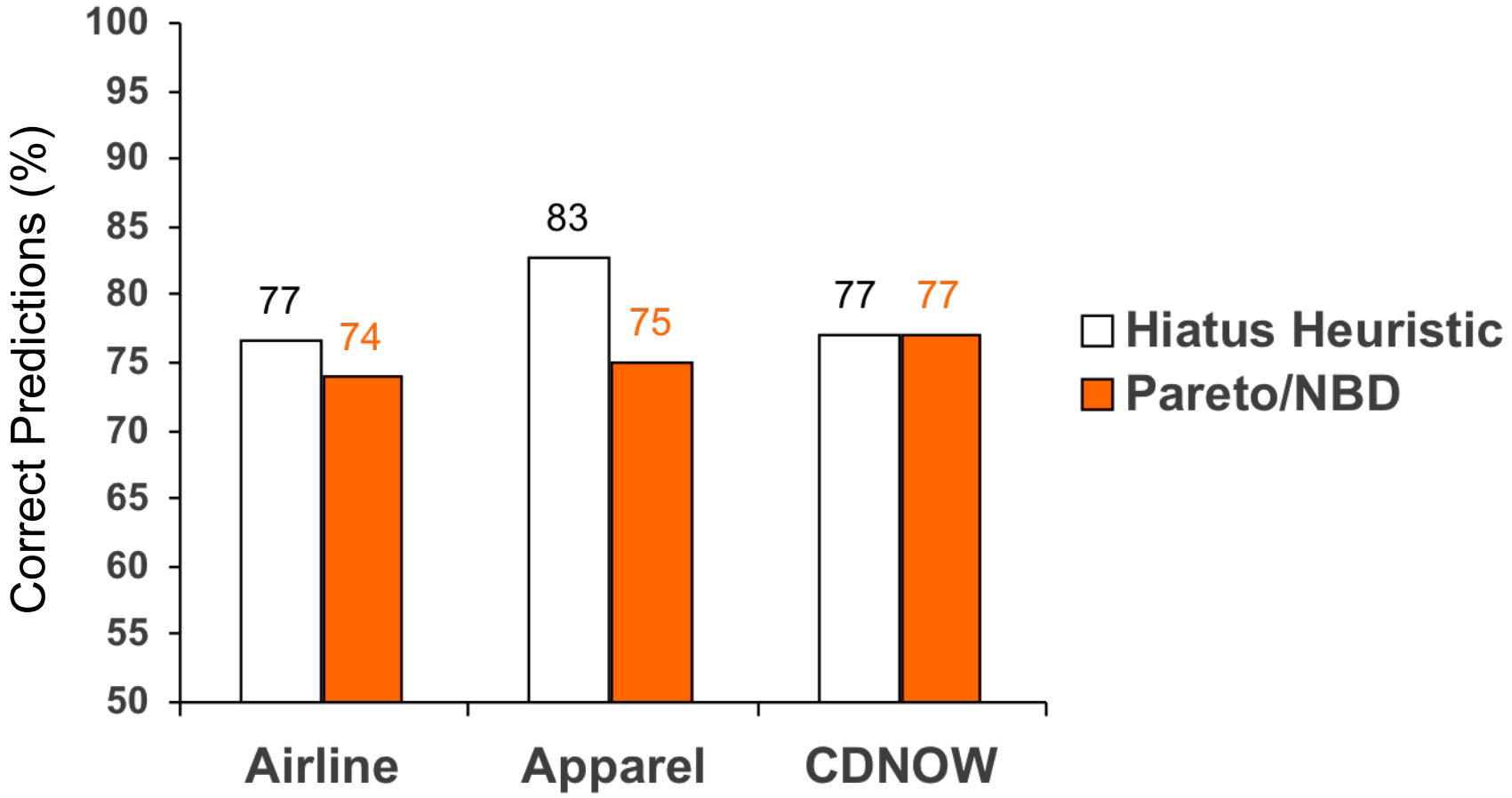
Psychological AI:

Use Heuristics to Make Computers Smart

Hiatus Heuristic:

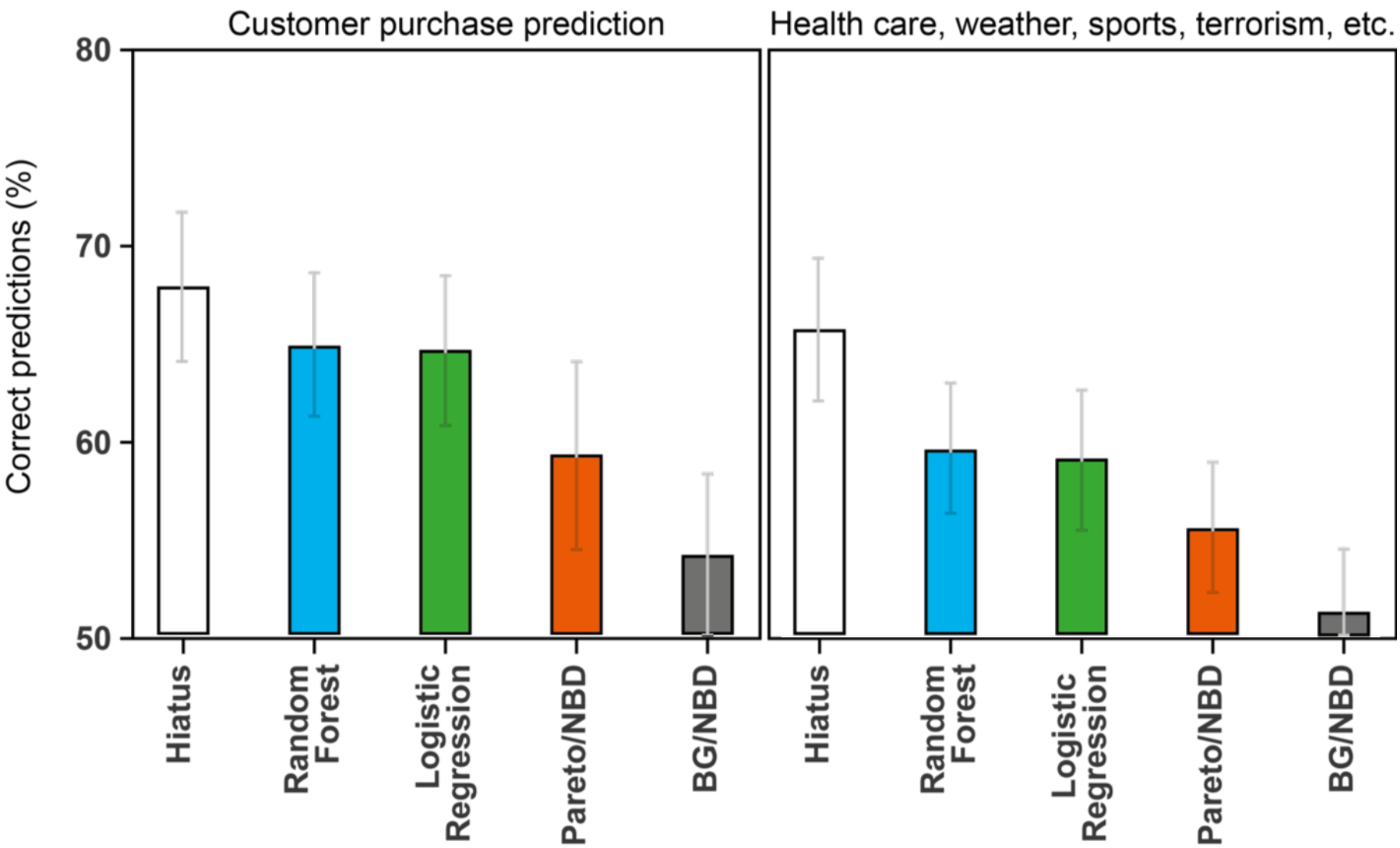
If a customer has not purchased within 9 months, classify as inactive, otherwise as active.

Predicting Future Customer Purchases: Less Is More.



Wübben, M., & Wangenheim, F. (2008). *Journal of Marketing*

Machine Learning Algorithms: Less Is Still More

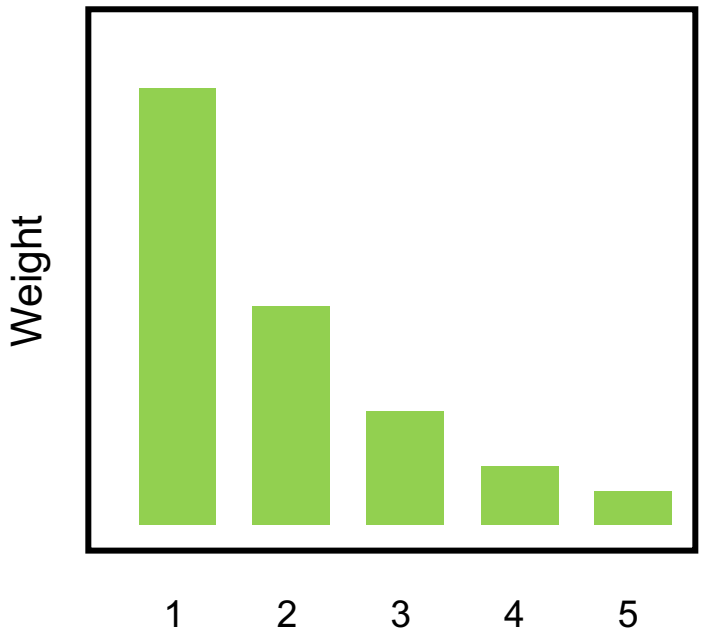


Average across 60 Studies. Artinger, F.M., von Wangenheim, F., & Gigerenzer, G. (2018)

ECOLOGICAL RATIONALITY OF ONE-REASON HEURISTICS

Dominant Cue. The weights w_1, w_2, w_3, …, w_n of n binary cues form a dominant-cue structure if they satisfy the constraint:

$$w_1 > \sum_{i=2}^{n} w_i$$



Gigerenzer 2021. What is bounded rationality? In R Viale (ed). *Routledge handbook of bounded rationality*.

Why Simple Heuristics?

Accuracy-effort trade-off

Payne, J. W., Bettman, J .R., & Johnson, E. J. (1993). *The adaptive decision maker*
Kahneman, D. (2011). *Thinking, fast and slow.*

total error = bias + noise

Why Simple Heuristics?

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total error = bias + noise

Bias-variance trade-off:
total error = $(\text{bias})^2$ + variance + noise

Out-of-Population Prediction

Geman, S., Bienenstock, E., & Doursat, R. (1992). *Neural Computation*
Brighton, H., & Gigerenzer, G. (2015). *Journal of Business Research*

Simple Heuristics Reduce Error from Variance

total error = $(\text{bias})^2$ + variance + noise

Bias, low variance

No bias, high variance

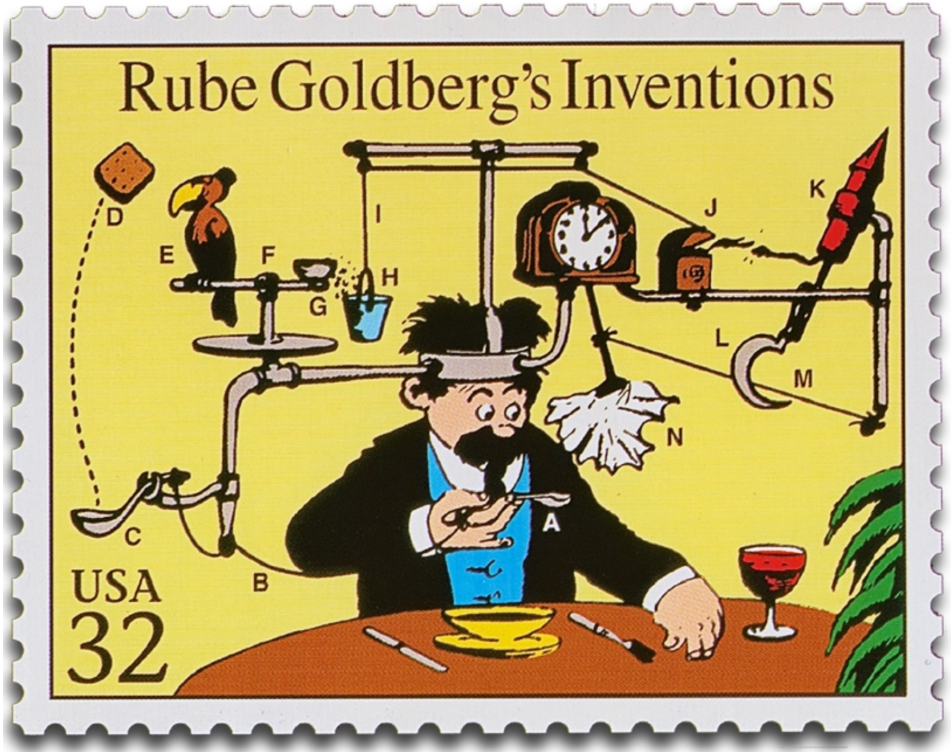
Geman, S., Bienenstock, E., & Doursat, R. (1992). *Neural Computation*
Gigerenzer, G., & Brighton, H. (2009). *Topics in Cognitive Science*

TURKEY ILLUSION

Out-of-Population-Prediction

Russell B. (1912). The *Problem of Philosophy*
Taleb N. & Blyth M. (2011)

Forecasting Methodology:
Always check whether there is a simple solution



The Self Operating Napkin: As you raise SPOON OF SOUP (A) to your mouth it pulls STRING (B), thereby jerking LADLE (C) which throws CRACKER (D) past PARROT (E). Parrot jumps after cracker and PERCH (F) tilts, upsetting SEEDS (G) into PAIL (H). Extra weight in pail pulls CORD (I) which opens and lights automatic cigar LIGHTER (J), setting off SKY-ROCKET (K) which causes SICKLE (L) to cut STRING (M) and allow pendulum with attached napkin to swing back and forth thereby wiping off your chin.

See also:

Green & Armstrong (2015). *Journal of Business Research*.

Makridakis, Spiliotis & Assimakopoulos (2020). *International Journal of Forecasting*.

Goldstein & Gigerenzer (2009). *International Journal of Forecasting*.

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