

*How do human beings reason when the conditions for rationality postulated by the model of neoclassical economics are NOT met?*

*Herbert A. Simon*

# *Homo Heuristicus*

*Why Biased Minds Make Better Inferences*

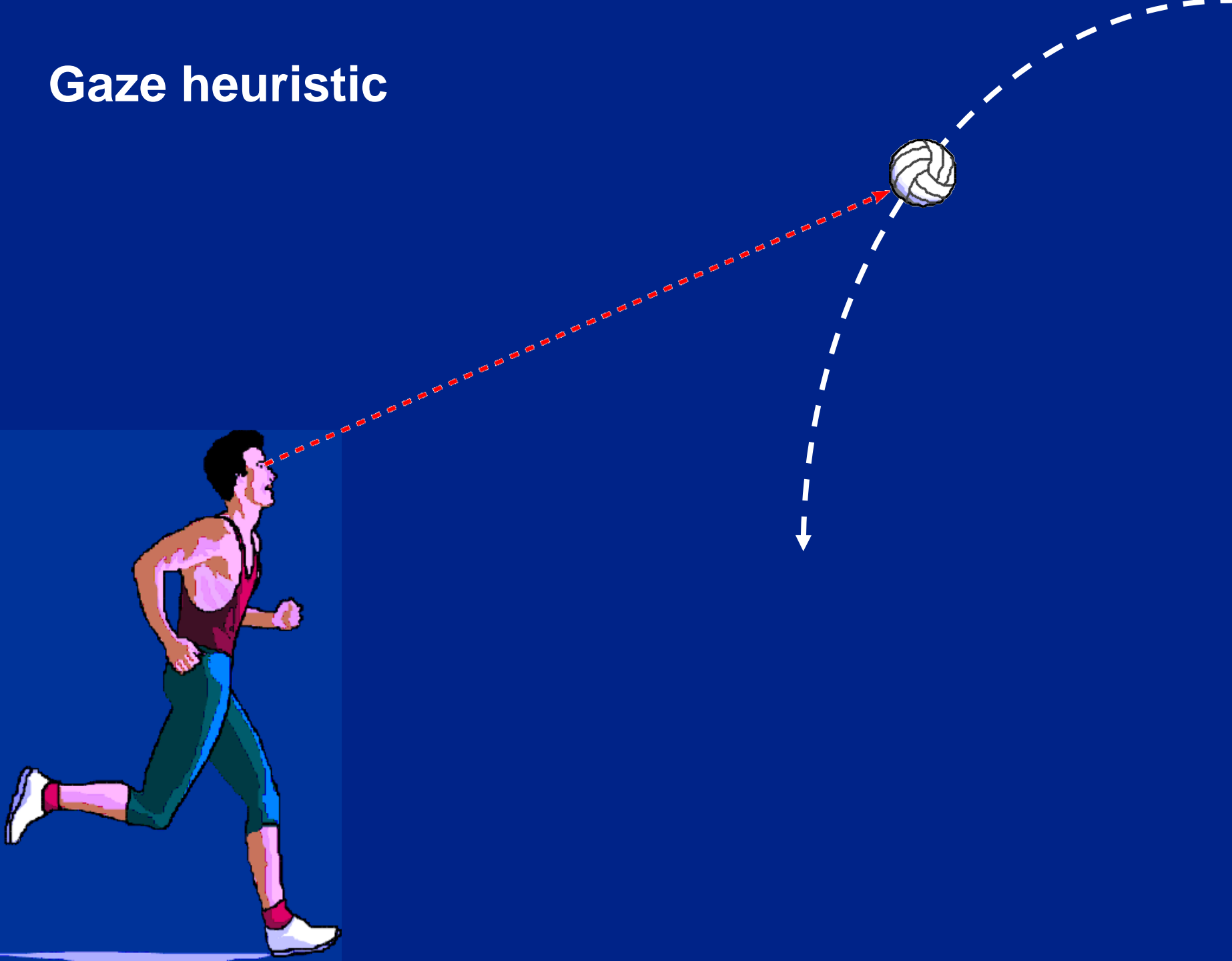
**Gerd Gigerenzer**



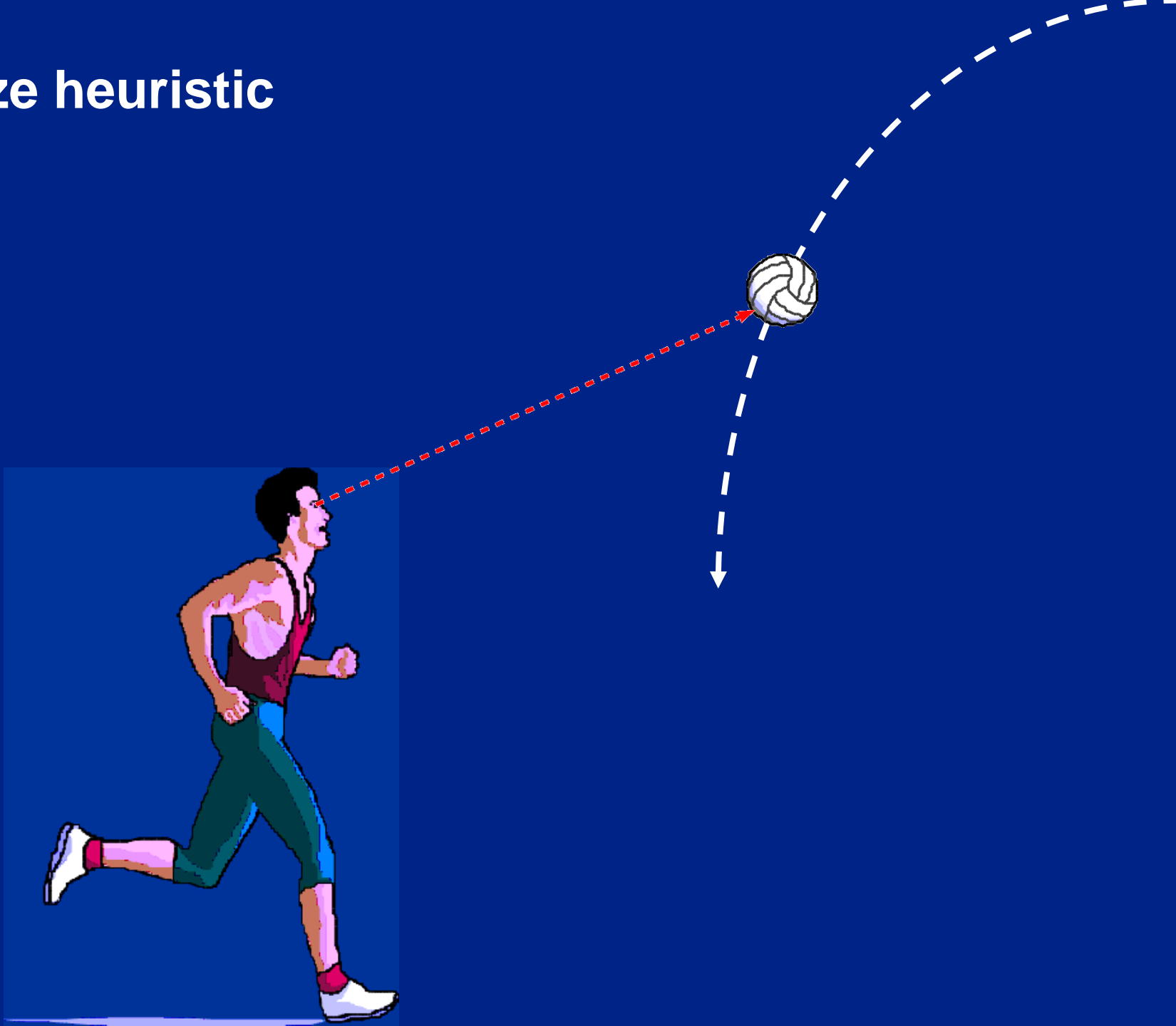
When a man throws a ball high in the air and catches it again, he behaves as if he had solved a set of differential equations in predicting the trajectory of the ball... At some subconscious level, something functionally equivalent to the mathematical calculation is going on.

*Richard Dawkins, The Selfish Gene*

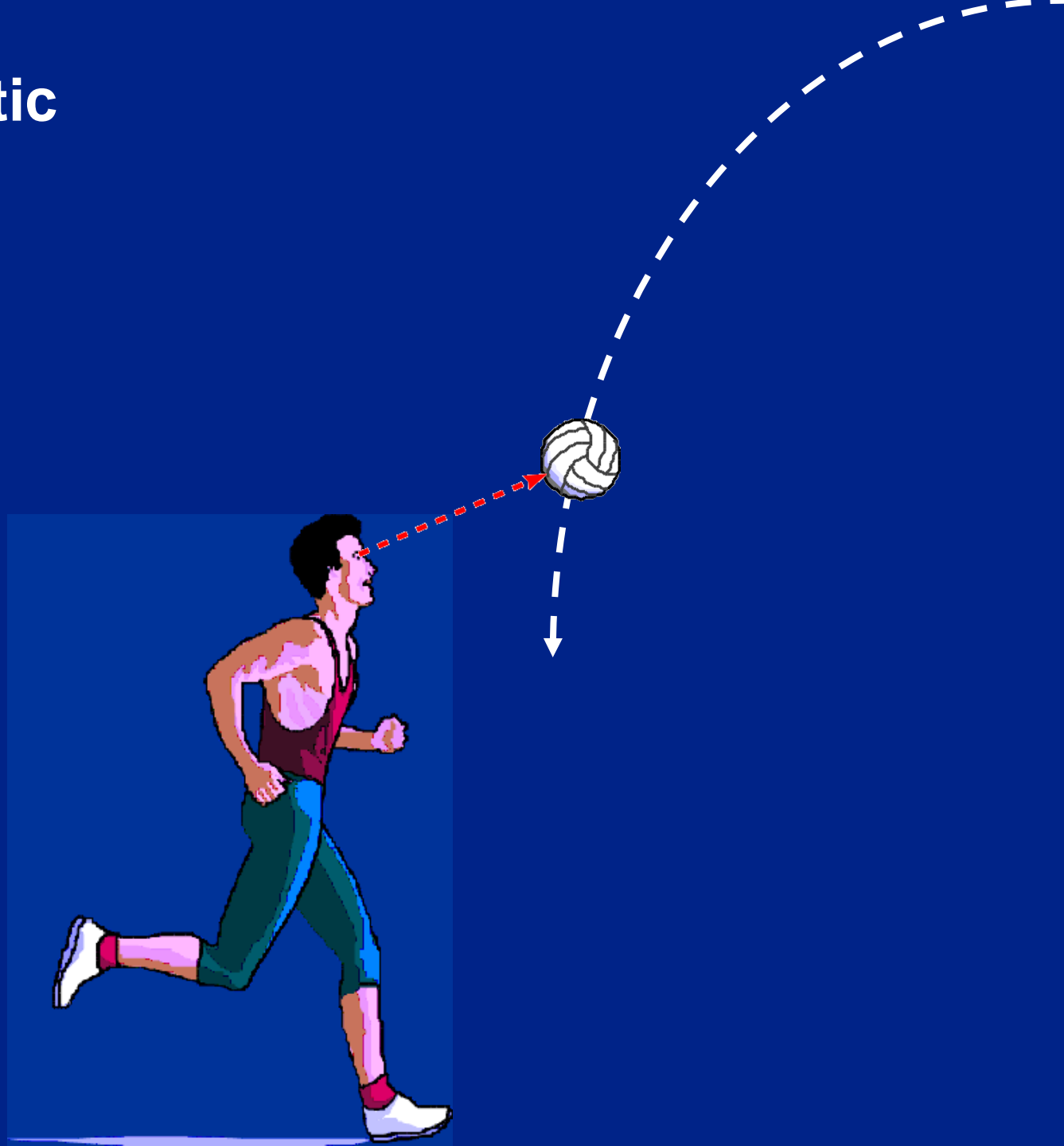
# Gaze heuristic



# Gaze heuristic



# Gaze heuristic



# Gaze heuristic



# As-if Models and Process Models

## Generate Different Predictions About Behavior

	<b>As-if model</b>	<b>Gaze heuristic</b>
Player's goal	Compute landing point	Intercept ball
Prediction 1	Runs to landing point and waits to catch ball	Intercepts ball while running✓
Prediction 2	Runs in a straight line	Runs in a slight arc✓
Prediction 3	Knows where the ball is landing	Does not know✓

# “The Miracle on the Hudson River”

US Airways Flight 1549



January 15, 2009



## Gaze heuristic

*Will the plane make it to LaGuardia Airport?*

“It’s not so much a mathematical calculation as visual, in that when you are flying in an airplane, a point that you can’t reach will actually rise in your windshield. A point that you are going to overfly will descend in your windshield.”

Jeffrey Skiles  
Co-pilot, US Airways Flight 1549

# Research Questions

## *I. The (Descriptive) Study of the Adaptive Toolbox*

What Heuristics Do People Use?

## *II. The (Normative) Study of Ecological Rationality*

When Are Heuristics Successful?

## *III. Intuitive Design*

How to Design Decision Systems and Environments?

# *I. The Study of the Adaptive Toolbox*

## **Research Questions**

What core capacities do heuristics exploit?

What are the building blocks of heuristics?

How do people learn and select heuristics in an adaptive way?

Gigerenzer & Gaissmaier (2011). Heuristic decision making. *Annual Review of Psychology*.

# Core Capacities and Heuristics in the Adaptive Toolbox

## 1. Recognition

Recognition heuristic: Goldstein & Gigerenzer, *Psychological Review* 2002

Fluency heuristic: Schooler & Hertwig, *Psychological Review* 2005

## 2. Divide Equally

1/N: DeMiguel et al. 2009, *Review of Financial Studies*

Tallying: Gigerenzer & Goldstein, *Psychological Review* 1996

## 3. Order

Fast-and-frugal trees: Martignon, Katsikopoulos, & Woike, *J of Math Psych* 2008

Take-the-best: Gigerenzer & Goldstein, *Psychological Review* 1996

Priority heuristic: Brandstätter, Gigerenzer, & Hertwig, *Psych Review* 2006, 2008

## 4. Reciprocity

Tit-for-tat: Volstorf, Rieskamp, & Stevens, *PLoS ONE*

## 5. Imitation

Imitate the majority/successful: Garcia-Retamero et al, in press.

## 6. Trust

Default heuristic: Pichert & Katsikopoulos, *J of Environmental Psychology* 2008

White-coat heuristic: Wegwarth & Gigerenzer, in press

# Core Capacities and Heuristics in the Adaptive Toolbox

## 1. Recognition

Recognition heuristic: Goldstein & Gigerenzer, *Psychological Review* 2002

Fluency heuristic: Schooler & Hertwig, *Psychological Review* 2005

## 2. Divide Equally

1/N: DeMiguel et al. 2009, *Review of Financial Studies*

Tallying: Gigerenzer & Goldstein, *Psychological Review* 1996

## 3. Order

Fast-and-frugal trees: Martignon, Katsikopoulos, & Woike, *J of Math Psych* 2008

Take-the-best: Gigerenzer & Goldstein, *Psychological Review* 1996

Priority heuristic: Brandstätter, Gigerenzer, & Hertwig, *Psych Review* 2006, 2008

## 4. Reciprocity

Tit-for-tat: Volstorf, Rieskamp, & Stevens, *PLoS ONE*

## 5. Imitation

Imitate the majority/successful: Garcia-Retamero et al, in press.

## 6. Trust

Default heuristic: Pichert & Katsikopoulos, *J of Environmental Psychology* 2008

White-coat heuristic: Wegwarth & Gigerenzer, in press

*Which US city has more inhabitants,  
Detroit or Milwaukee?*

*Americans:*

**60%**

*correct*

*Germans:*

**90%**

*correct*

# *Recognition Heuristic*

*If one of two objects is recognized and the other is not, then infer that the recognized object has the higher value.*

## *Ecological Rationality*

*The heuristic is successful  
when ignorance is systematic rather than random,  
that is, when the recognition validity  $\alpha > .5$ .*

**Today:**  
**Man**

# Manchester United vs. Shrewsbury Town

A soccer player in a red and white striped jersey (number 10) is being tackled by a player in a green jersey (number 1) on a grass field. The player in the red and white jersey is in the air, having just kicked the ball, while the player in the green jersey is sliding in to tackle him. The background is a blurred stadium crowd.

[illegible]



# The Less-is-More Effect

The expected proportion of correct inferences  $c$  is

$$C = \frac{2n(N - n)}{N(N - 1)} \alpha + \frac{(N - n)(N - n - 1)}{N(N - 1)} \frac{1}{2} + \frac{n(n - 1)}{N(N - 1)} \beta$$

where

$n$  is the number of recognized objects

$N$  is the total number of objects

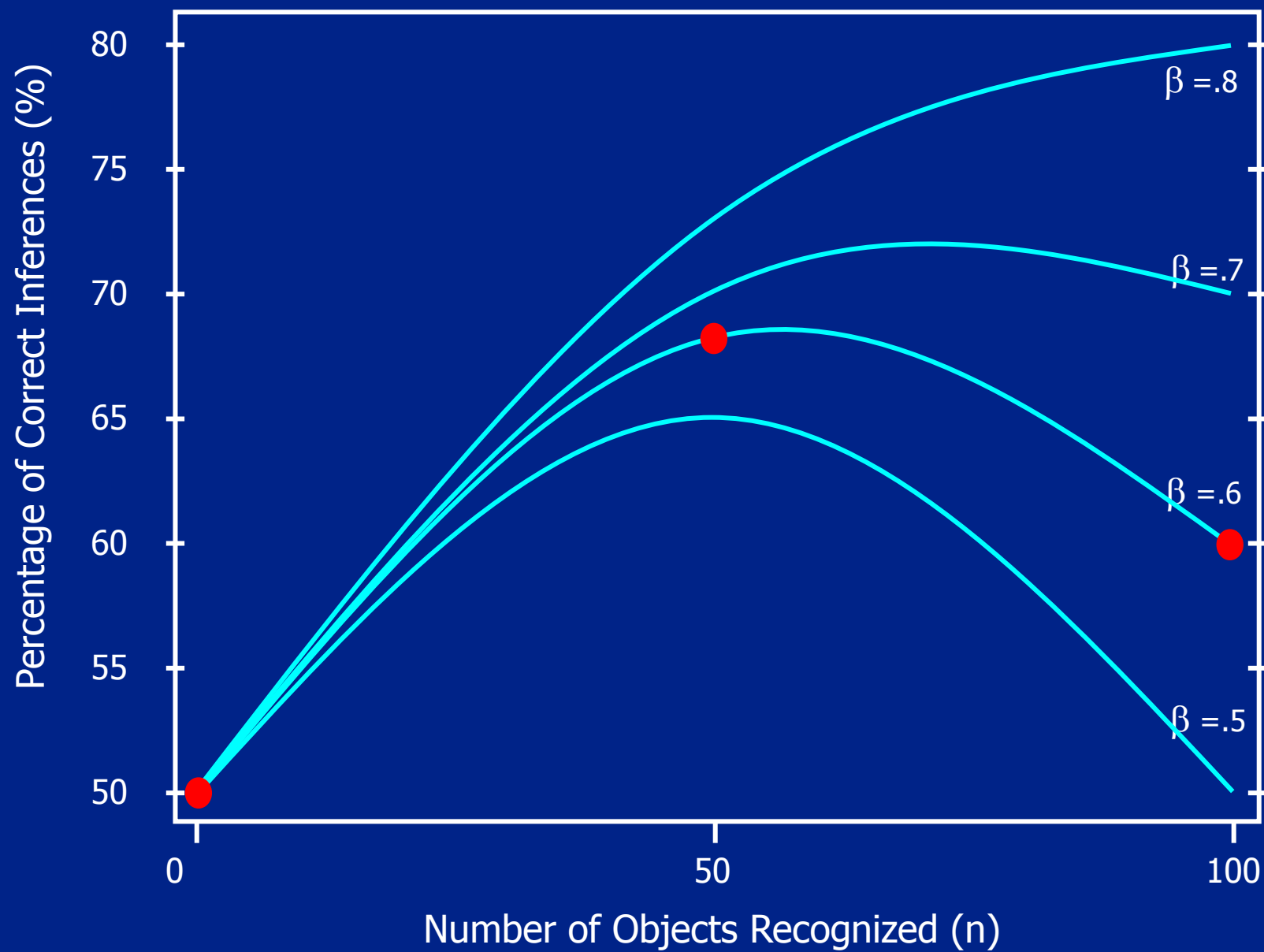
$\alpha$  is the recognition validity, and

$\beta$  is the knowledge validity

A less-is-more effect occurs when

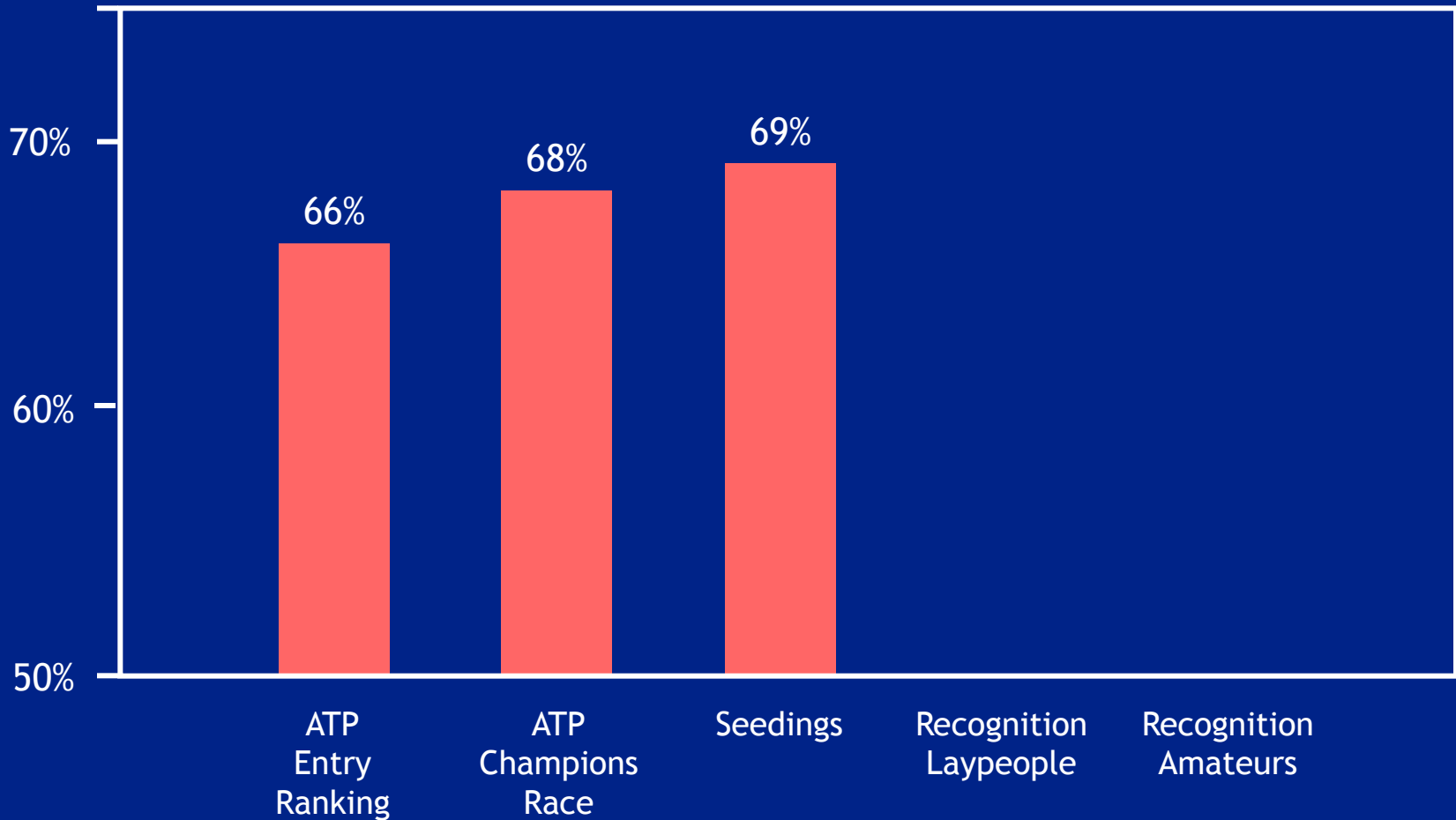
$$\alpha > \beta$$

$$\alpha = .8$$



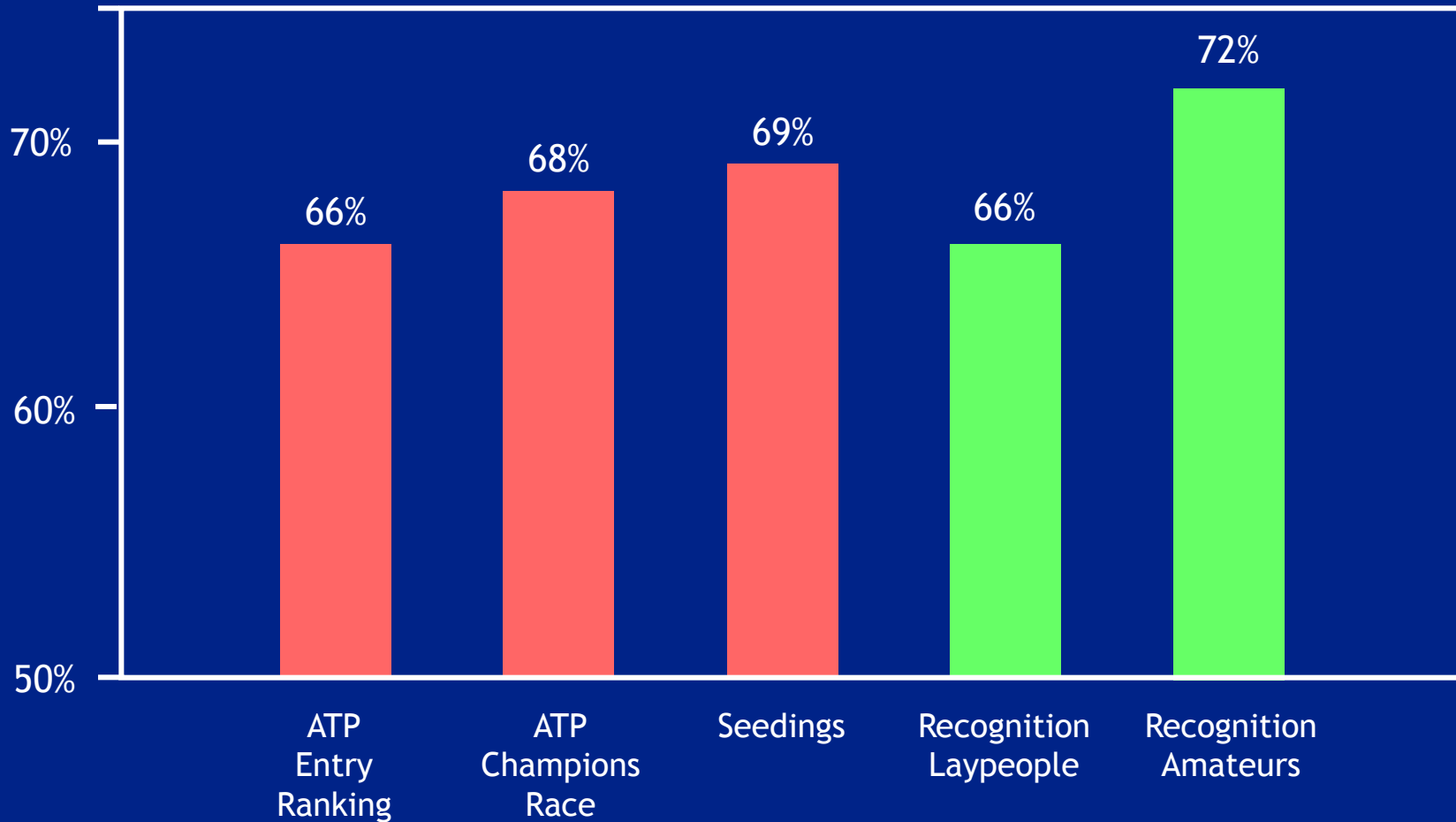
# *Wimbledon 2003*

Correct  
Predictions



# *Wimbledon 2003*

Correct  
Predictions



# Research Questions

## *I. The (Descriptive) Study of the Adaptive Toolbox*

What Heuristics Do People Use?

## *II. The (Normative) Study of Ecological Rationality*

When Are Heuristics Successful?

## *III. Intuitive Design*

How to Design Decision Systems and Environments?

## *II. The Study of Ecological Rationality*

### **Research Questions**

What environmental structures – social and physical – can heuristics exploit?

How do simplicity, robustness, and bias lead to better decisions?

Do rational analyses of “small” worlds tell us what is rational in uncertain worlds?

Todd, Gigerenzer, & ABC Research Group, in press. *Ecological rationality; Intelligence in the world*.  
Oxford University Press

# Core Capacities and Heuristics in the Adaptive Toolbox

## 1. Recognition

Recognition heuristic: Goldstein & Gigerenzer, *Psychological Review* 2002

Fluency heuristic: Schooler & Hertwig, *Psychological Review* 2005

## 2. Divide Equally

1/N: DeMiguel et al. 2009, *Review of Financial Studies*

Tallying: Gigerenzer & Goldstein, *Psychological Review* 1996

## 3. Order

Fast-and-frugal trees: Martignon, Katsikopoulos, & Woike, *J of Math Psych* 2008

Take-the-best: Gigerenzer & Goldstein, *Psychological Review* 1996

Priority heuristic: Brandstätter, Gigerenzer, & Hertwig, *Psych Review* 2006, 2008

## 4. Reciprocity

Tit-for-tat: Volstorf, Rieskamp, & Stevens, *PLoS ONE*

## 5. Imitation

Imitate the majority/successful: Garcia-Retamero et al, in press.

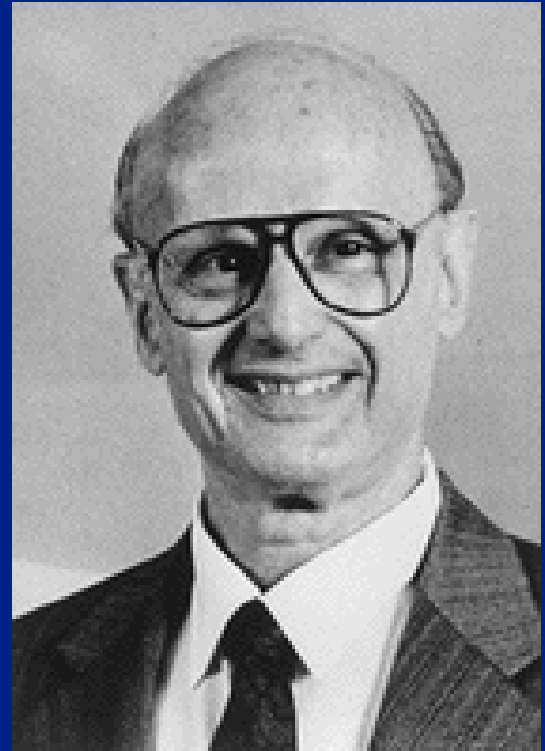
## 6. Trust

Default heuristic: Pichert & Katsikopoulos, *J of Environmental Psychology* 2008

White-coat heuristic: Wegwarth & Gigerenzer, in press

# How to make investment decisions?

*Optimal Asset Allocation Policy*  
*“Mean-Variance-Model”*



Harry Markowitz

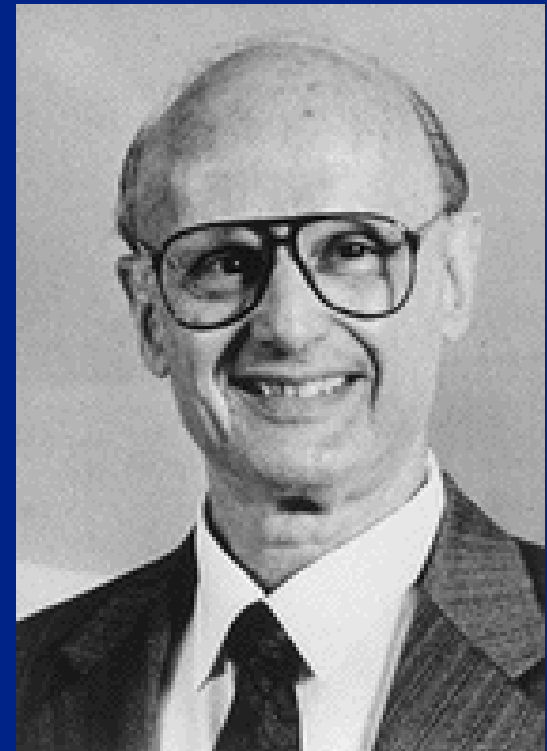


# Optimization or Heuristic?

~~*Optimal Asset Allocation Policy*~~  
~~*“Mean-Variance-Model”*~~

*1/N*

*Allocate your money equally  
to each of N funds*



Harry Markowitz

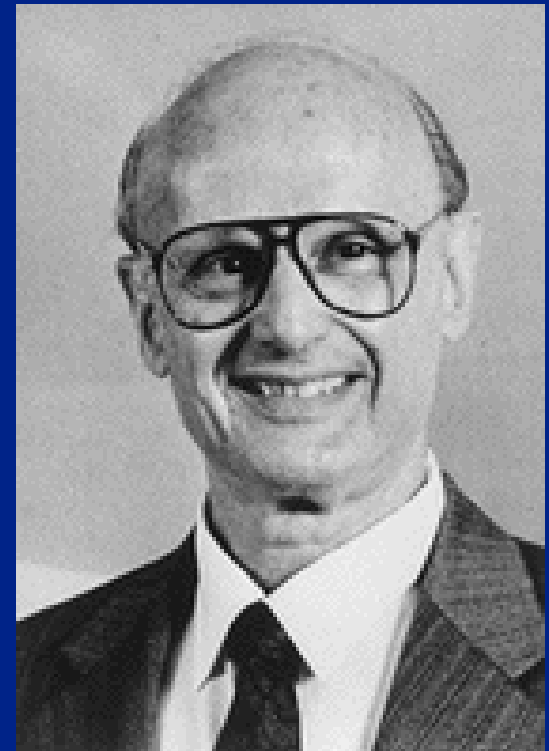
# When Is $1/N$ Better Than Optimization?

$1/N$

*Allocate your money equally  
to each of  $N$  funds*

**$1/N$  is ecologically rational if:**

1. Predictive uncertainty: **large**
2.  $N$ : **large**
3. Learning sample: **small**



Harry Markowitz

# Mit nobelpreisgekrönter Strategie zum Anlageerfolg!

Kennen Sie Harry M. Markowitz? Nein? Dann sollten Sie ihn kennenlernen: Der amerikanische Wissenschaftler erhielt im Jahr 1990 den Nobelpreis für Wirtschaftswissenschaften. Mit seiner Portfoliotheorie hatte er nachgewiesen, dass die richtige Gewichtung von Einzelwerten das Chancen-Sicherheits-Verhältnis eines Wertpapierdepots erheblich optimieren kann.

So viel zur Theorie. Die Depots der meisten Anleger sehen jedoch anders aus. Da sie oftmals eher willkürlich denn systematisch zusammengestellt worden sind besteht starker Optimierungsbedarf.



*II. The Study of Ecological Rationality*

**Simplicity Fosters Robustness**

**But How to Simplify?**

# Core Capacities and Heuristics in the Adaptive Toolbox

## 1. Recognition

Recognition heuristic: Goldstein & Gigerenzer, *Psychological Review* 2002

Fluency heuristic: Schooler & Hertwig, *Psychological Review* 2005

## 2. Divide Equally

1/N: DeMiguel et al. 2009, *Review of Financial Studies*

Tallying: Gigerenzer & Goldstein, *Psychological Review* 1996

## 3. Order

Fast-and-frugal trees: Martignon, Katsikopoulos, & Woike, *J of Math Psych* 2008

Take-the-best: Gigerenzer & Goldstein, *Psychological Review* 1996

Priority heuristic: Brandstätter, Gigerenzer, & Hertwig, *Psych Review* 2006, 2008

## 4. Reciprocity

Tit-for-tat: Volstorf, Rieskamp, & Stevens, *PLoS ONE*

## 5. Imitation

Imitate the majority/successful: Garcia-Retamero et al, in press.

## 6. Trust

Default heuristic: Pichert & Katsikopoulos, *J of Environmental Psychology* 2008

White-coat heuristic: Wegwarth & Gigerenzer, in press

# *Heuristics have biases (ignore information) to improve out-of-sample prediction*

## Take-the-best

*Search rule:* Look up the cue with the highest validity.

*Stopping rule:* If cue values differ (+/-), stop search. If not, look up next cue.

*Decision rule:* Predict that the alternative with the positive cue value has the higher criterion value.

**Bias: ignore cues**

## Tallying

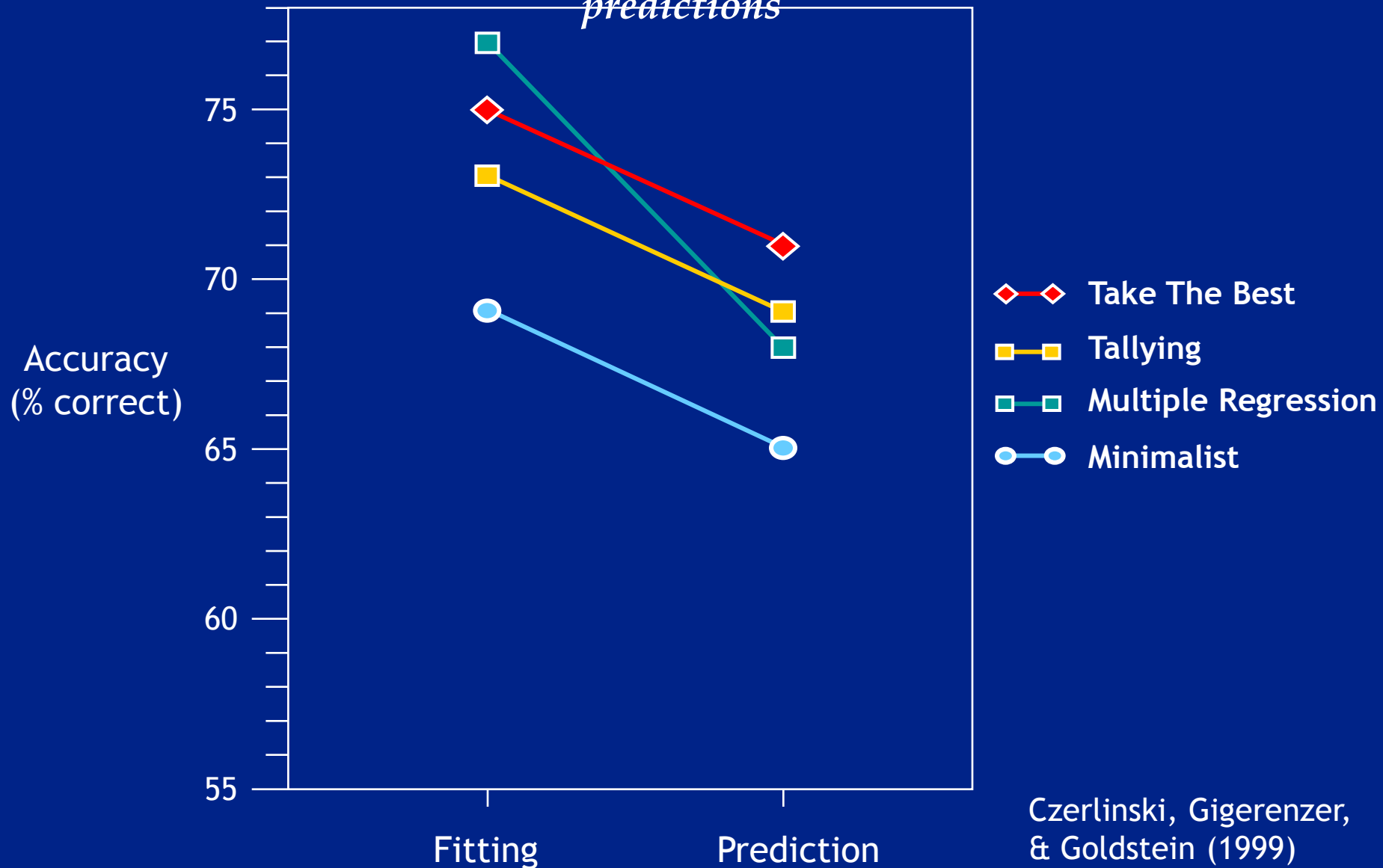
*Search rule:* Look up cues in random order.

*Stopping rule:* After  $m$  ( $1 < m \leq M$ ) cues, stop search.

*Decision rule:* Predict that the alternative with the higher number of positive cue values has the higher criterion value.

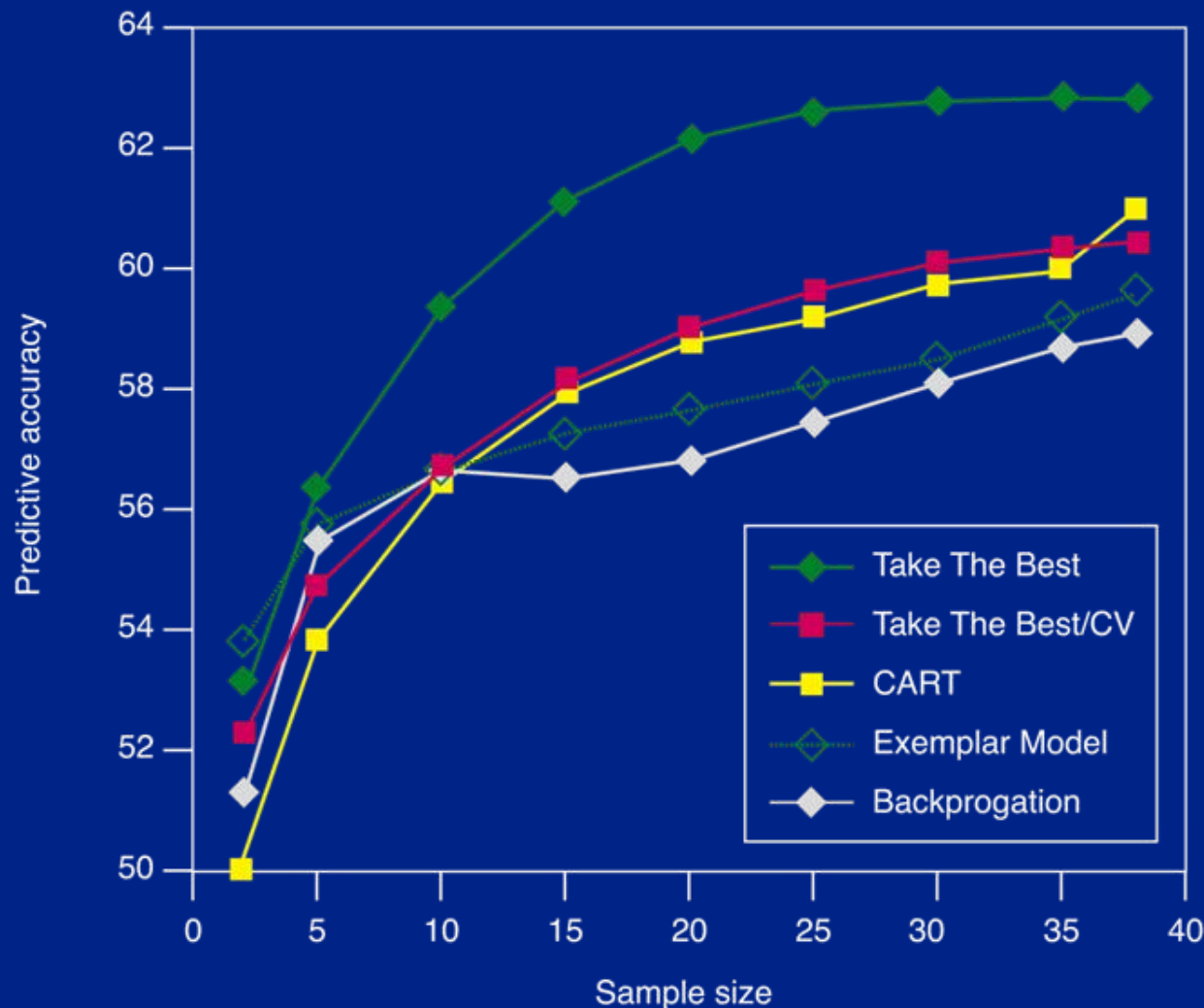
**Bias: ignore weights**

*Less Can Be More:  
20 Studies on economic, educational, and psychological  
predictions*



# Which Chicago High School has the higher drop-out rate?

Cues: attendance rate, writing score, social science test score, % Hispanic students, % students with limited English, % African American students, etc



## Policy Implications

*Take-the-best:*  
attendance rate;  
writing score; social  
science score.

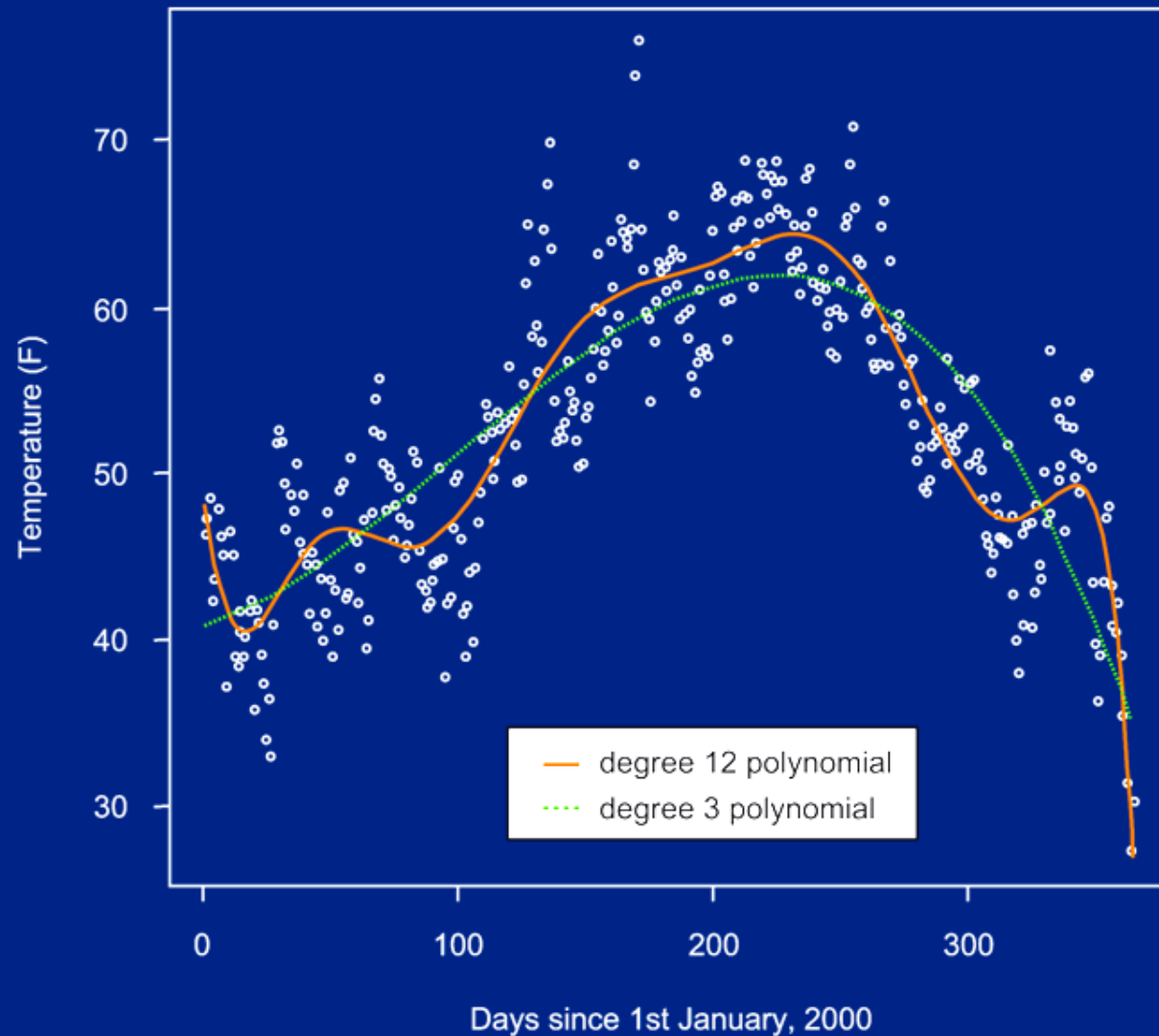
*Multiple regression:*  
percentage of  
Hispanic and Black  
students,  
students with limited  
English.



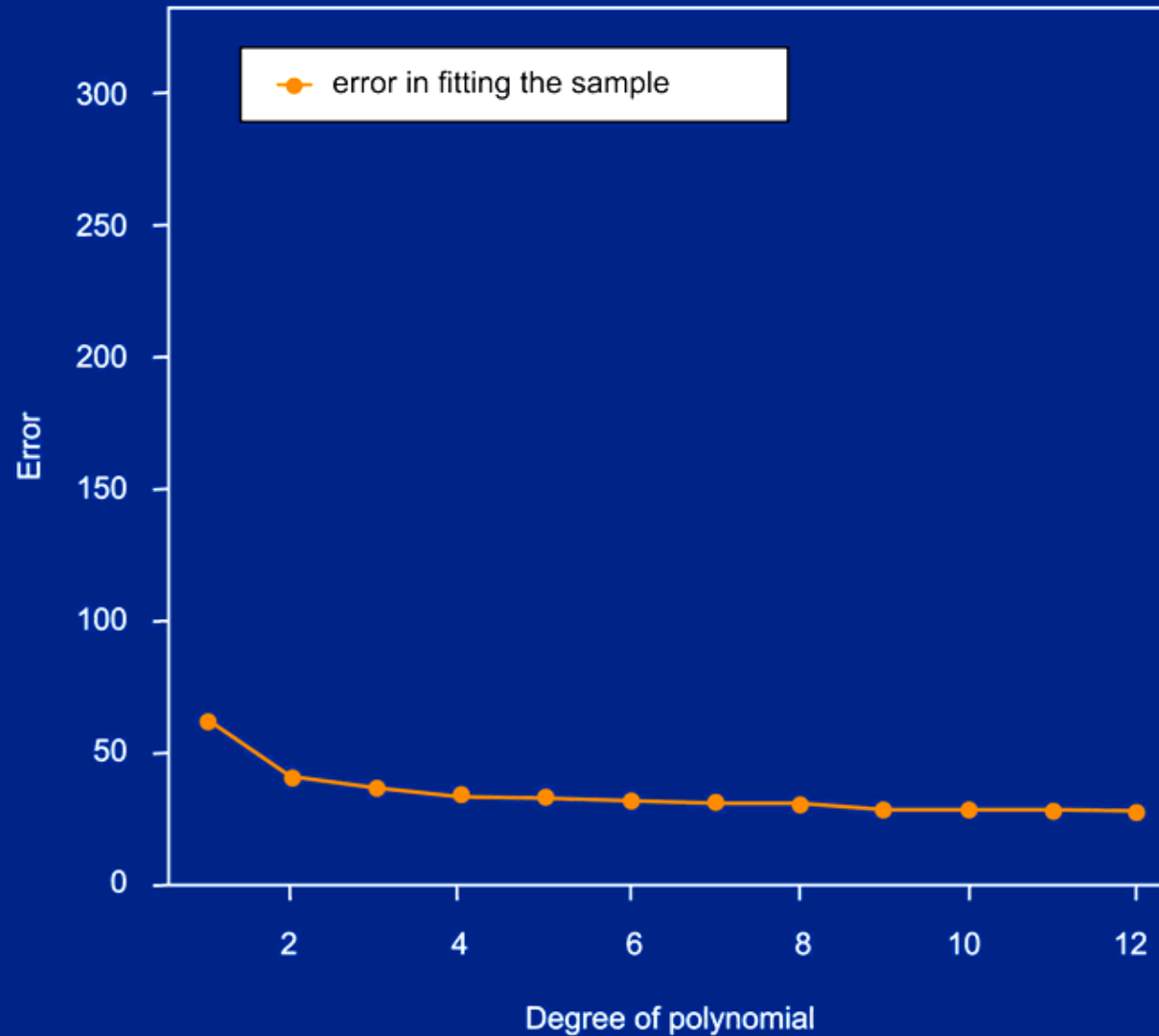
# The Bias-Variance Dilemma in Prediction

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

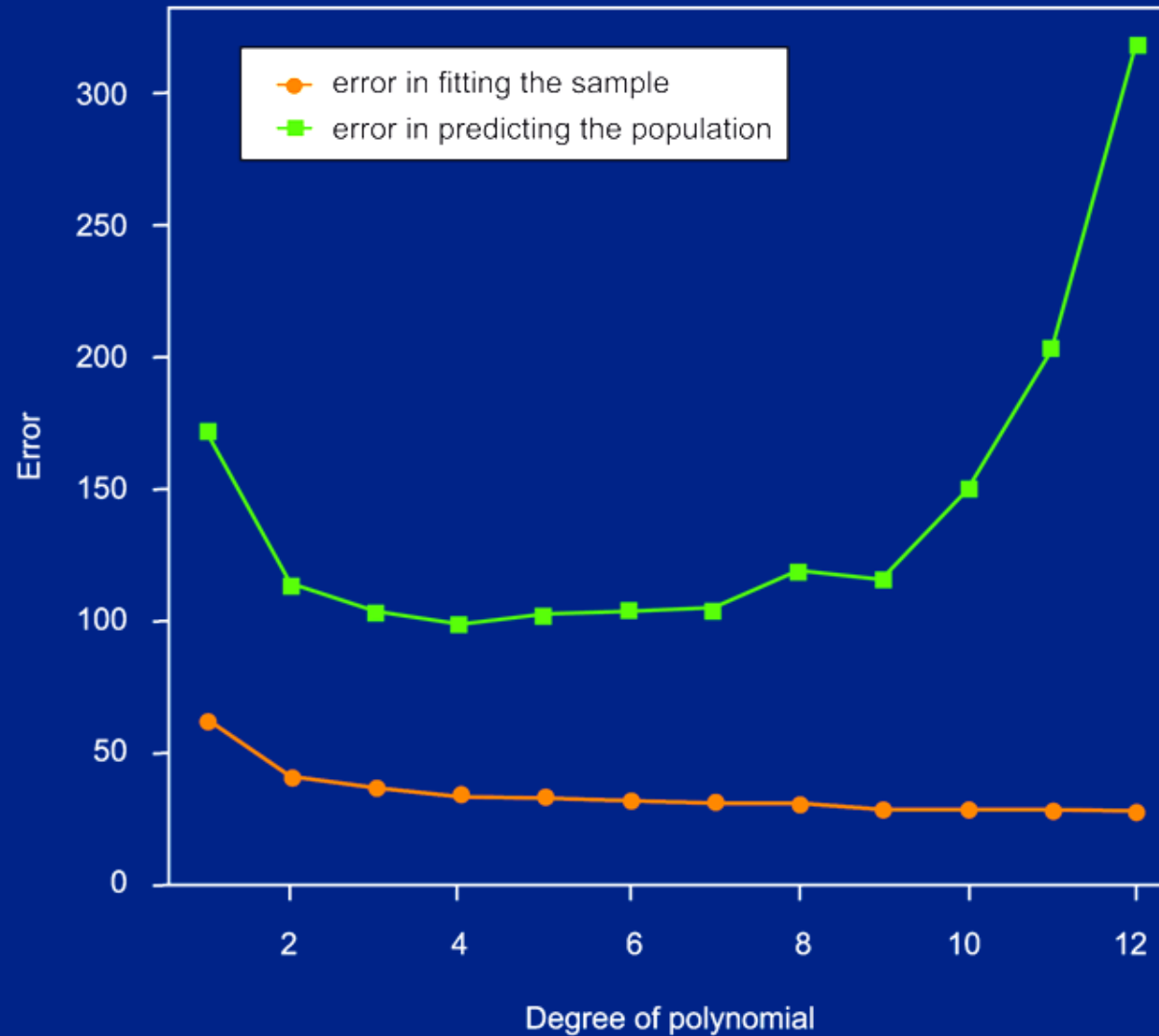
# Temperature in London 2000



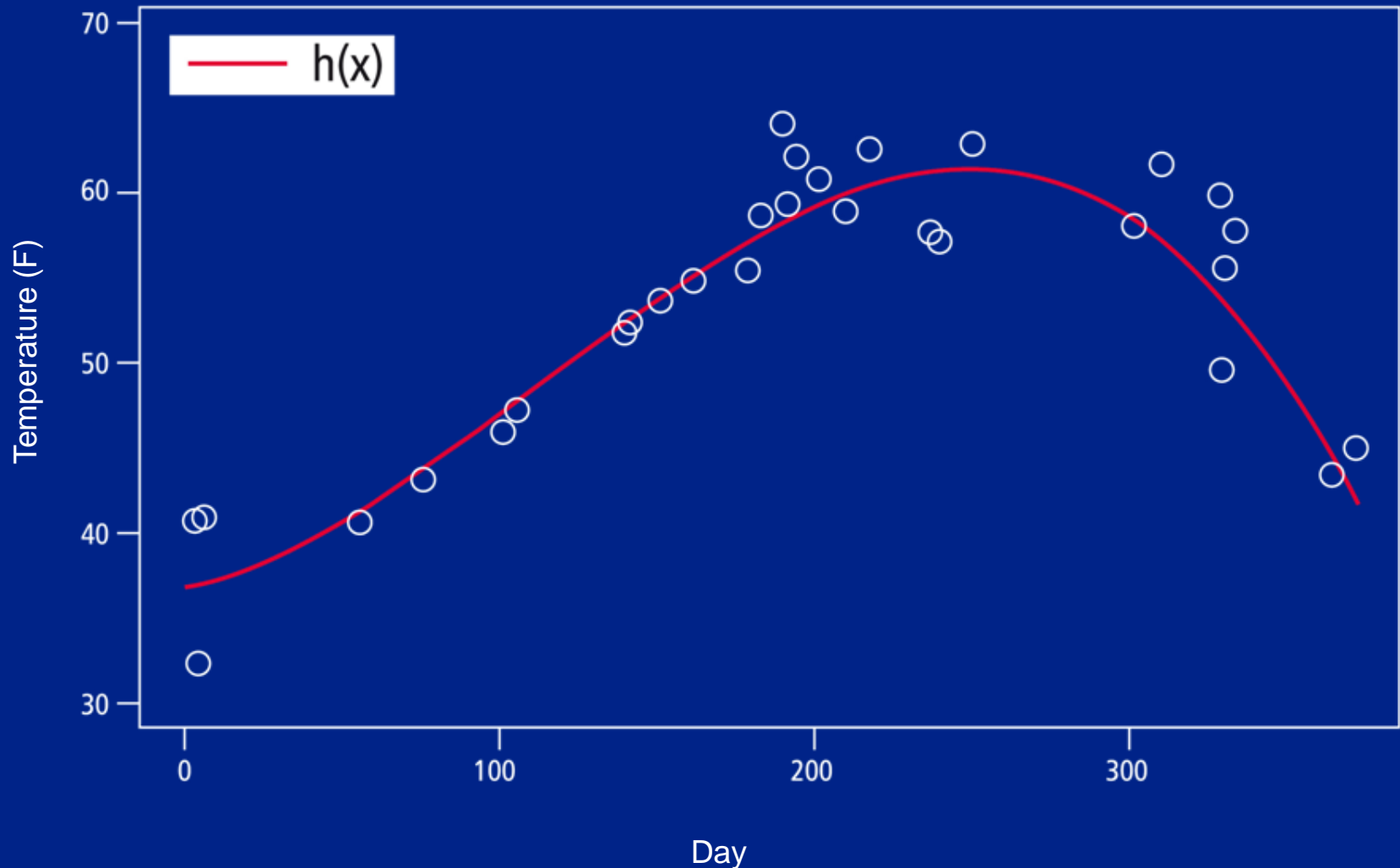
# More Is Better - Better Insight (Fitting)



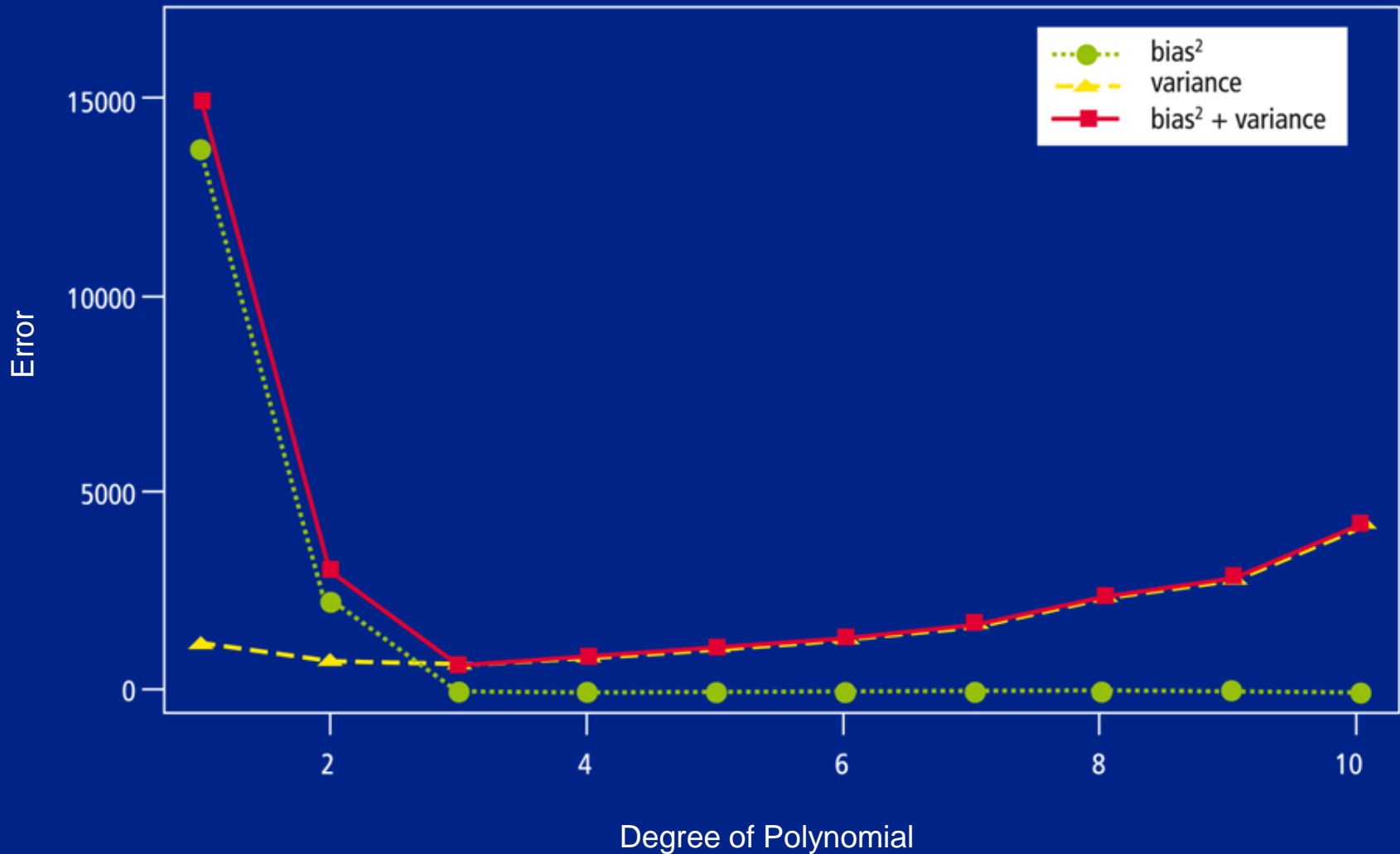
# Less-Is-More in Prediction



# A Fictional Temperature Function $h(x)$ to Demonstrate Bias and Variance



# Bias and Variance in Prediction



# Research Questions

## *I. The (Descriptive) Study of the Adaptive Toolbox*

What Heuristics Do People Use?

## *II. The (Normative) Study of Ecological Rationality*

When Are Heuristics Successful?

## *III. Intuitive Design*

How to Design Decision Systems and Environments?

### III. How to Design Decision Systems and Environments? Intuitive Design

#### **Research Questions**

How to design expert systems that embody intuitive principles?

How to design environments – social and physical – that match intuitive principles?



# The heart disease predictive instrument (HDPI)

## Chest Pain = Chief Complaint

### EKG (ST, T wave Δ's)

History	ST&T Ø	ST↔	T↑↓	ST↔	ST↔&T↑↓	ST↑↓&T↑↓
No MI& No NTG	19%	35%	42%	54%	62%	78%
MI or NTG	27%	46%	53%	64%	73%	85%
MI and NTG	37%	58%	65%	75%	80%	90%

## Chest Pain, NOT Chief Complaint

### EKG (ST, T wave Δ's)

History	ST&T Ø	ST↔	T↑↓	ST↔	ST↔&T↑↓	ST↑↓&T↑↓
No MI& No NTG	10%	21%	26%	36%	45%	64%
MI or NTG	16%	29%	36%	48%	56%	74%
MI and NTG	22%	40%	47%	59%	67%	82%

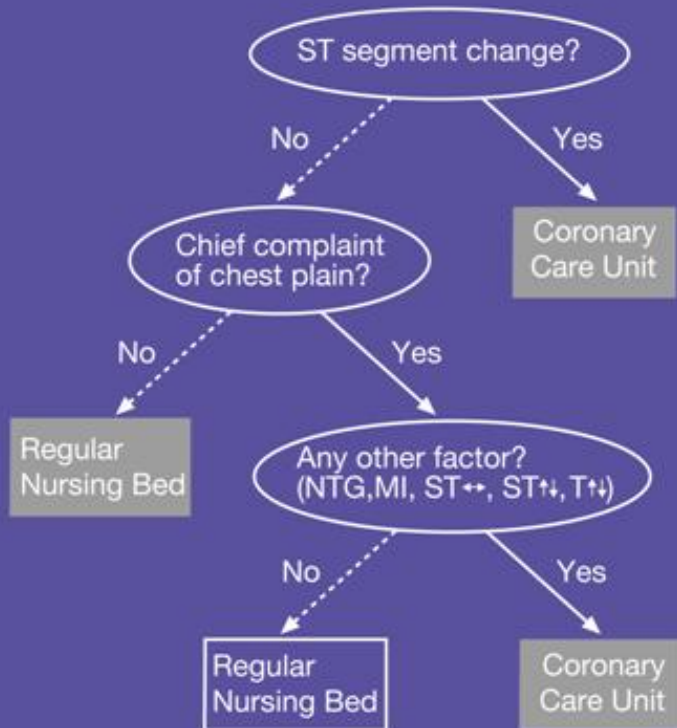
## No Chest Pain

### EKG (ST, T wave Δ's)

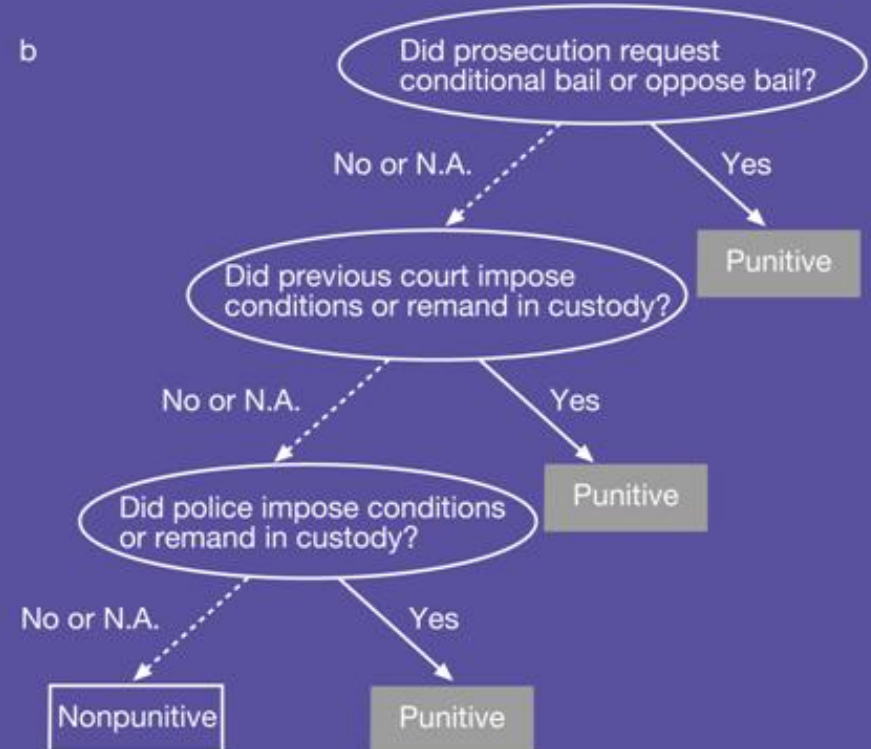
See reverse for definitions and instructions

# Fast-and-Frugal Trees: Deliberate and Intuitive Judgments

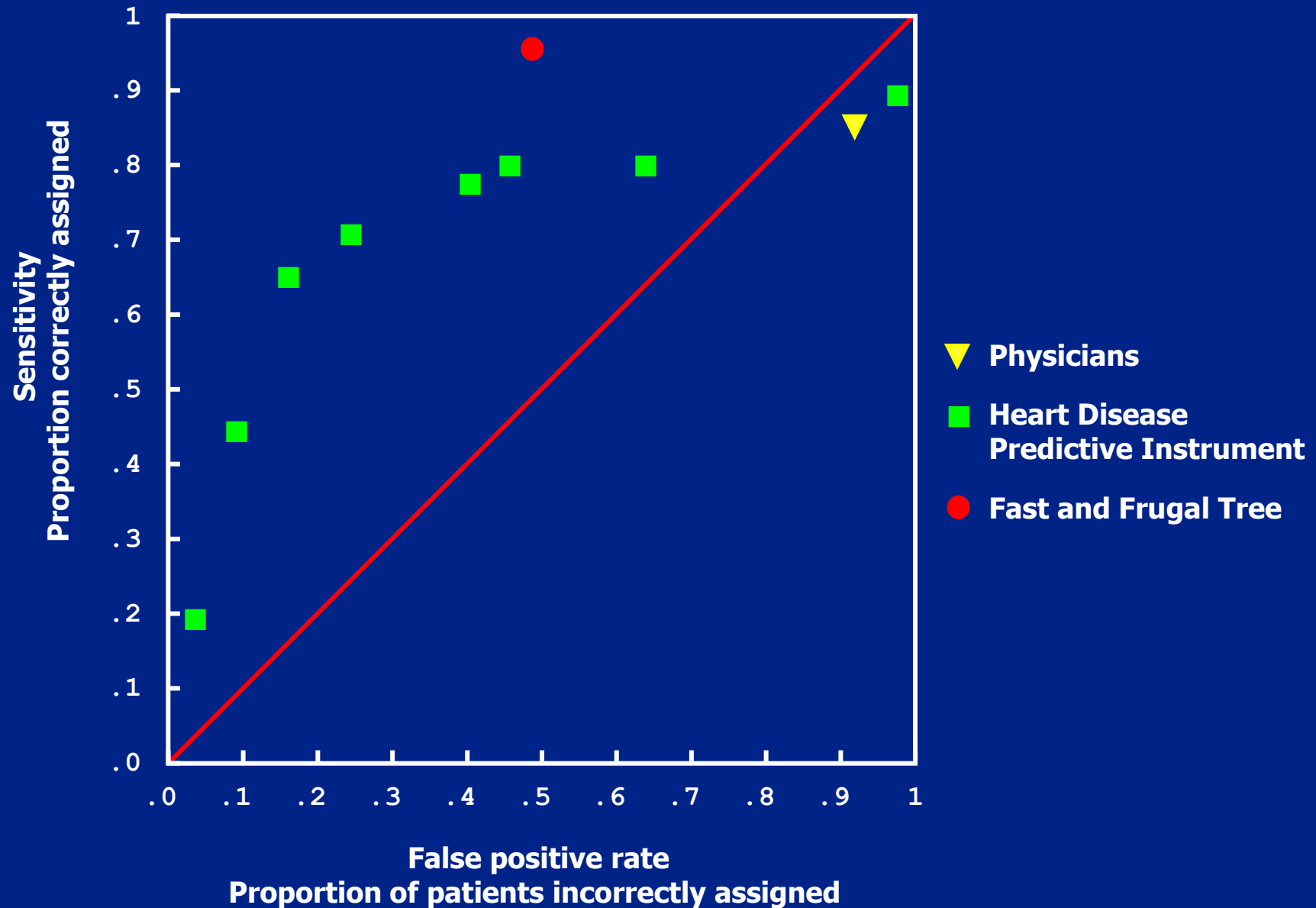
*Coronary Care Unit Allocation*



*Bail Decisions in London Courts*

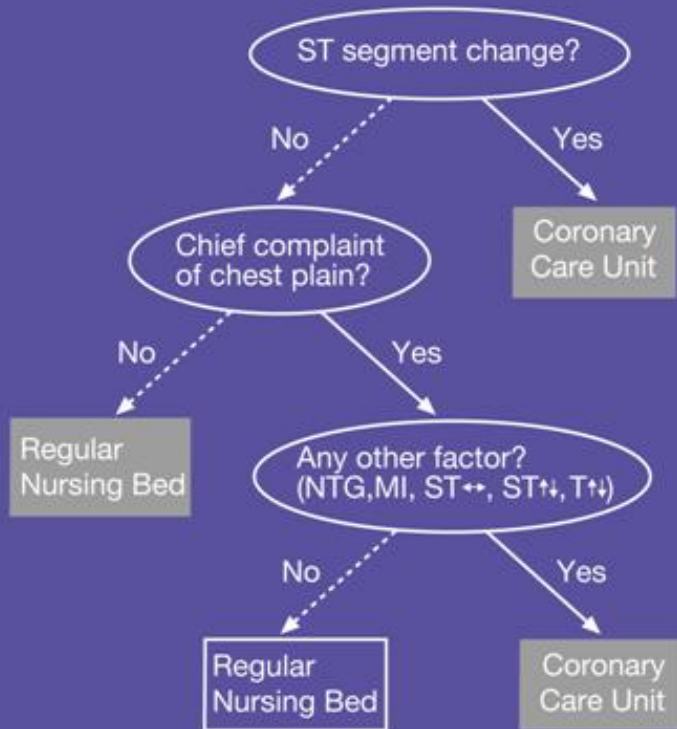


# *Emergency Room Decisions: Admit to the Coronary Care Unit?*



# Fast-and-Frugal Trees: Deliberate and Intuitive Judgments

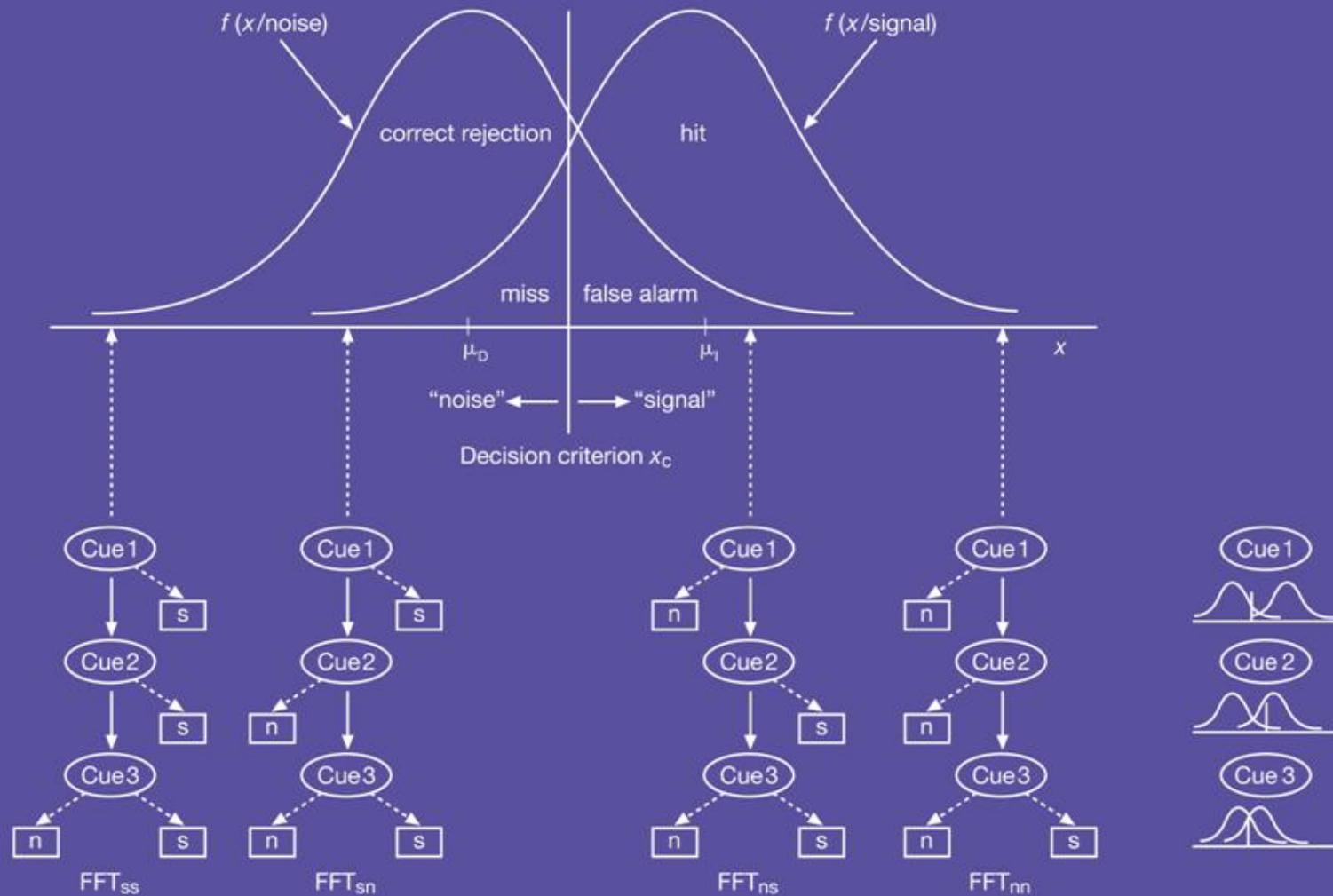
*Coronary Care Unit Allocation*



*Bail Decisions in London Courts*



# A Signal-Detection-Analysis of Fast-and-Frugal Trees



# Three Misconceptions

1. *Heuristics produce second-best results; optimization models are always better.*
2. *People rely on heuristics because of the accuracy-effort trade-off.*
3. *More information, time, and computation is always better.*

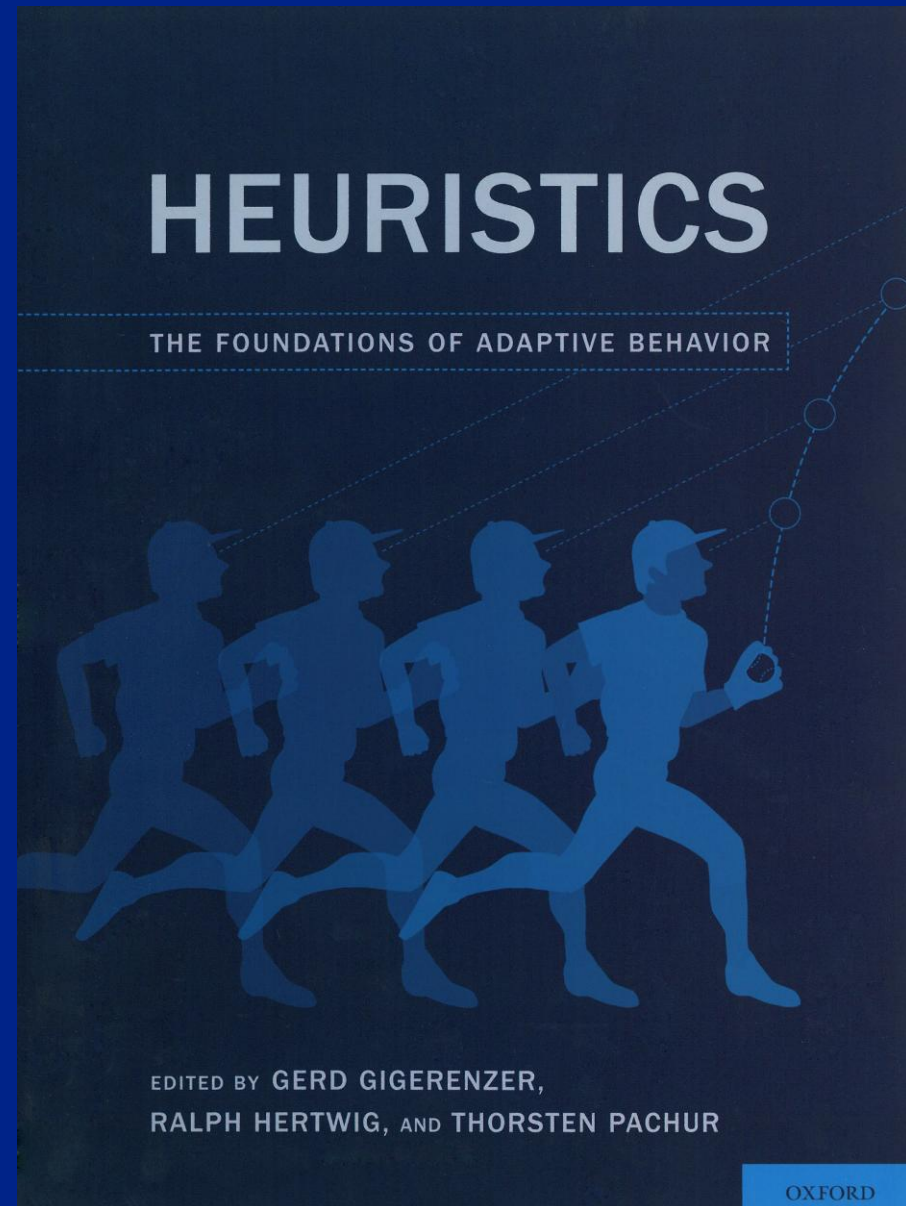
# Rationality in uncertain worlds

*Heuristics ignore information (Bias)*

*Bias protects against Variance*

*Less-is-more:  
Heuristics can make better inferences  
than complex models*

*Ecological rationality*



Oxford UP 2011