Ockham‘s Razor

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Outline

- General Overview
- Historic Perception
- Principles & Example
- Philosophic Perspective

General Overview

Role

- „From theories fitting the data equally well, scientists should choose the simplest one.“
- Fit is not the only criterion.
- Explanatory power, predictive accuracy, testability,… and **parsimony** must be considered.

- Synonyms:
  - Principle of Simplicity
  - Principle of Economy
  - Ockham‘s Razor
- Parsimony is cross-disciplinary.

Importance

- No scientific conclusion (or inference) without parsimony.
- Parsimonious models can be much more efficient (data collection, calc time).

„Scientists want to find the truth, but don‘t want to spend more time or money than necessary.“

Historic Perception

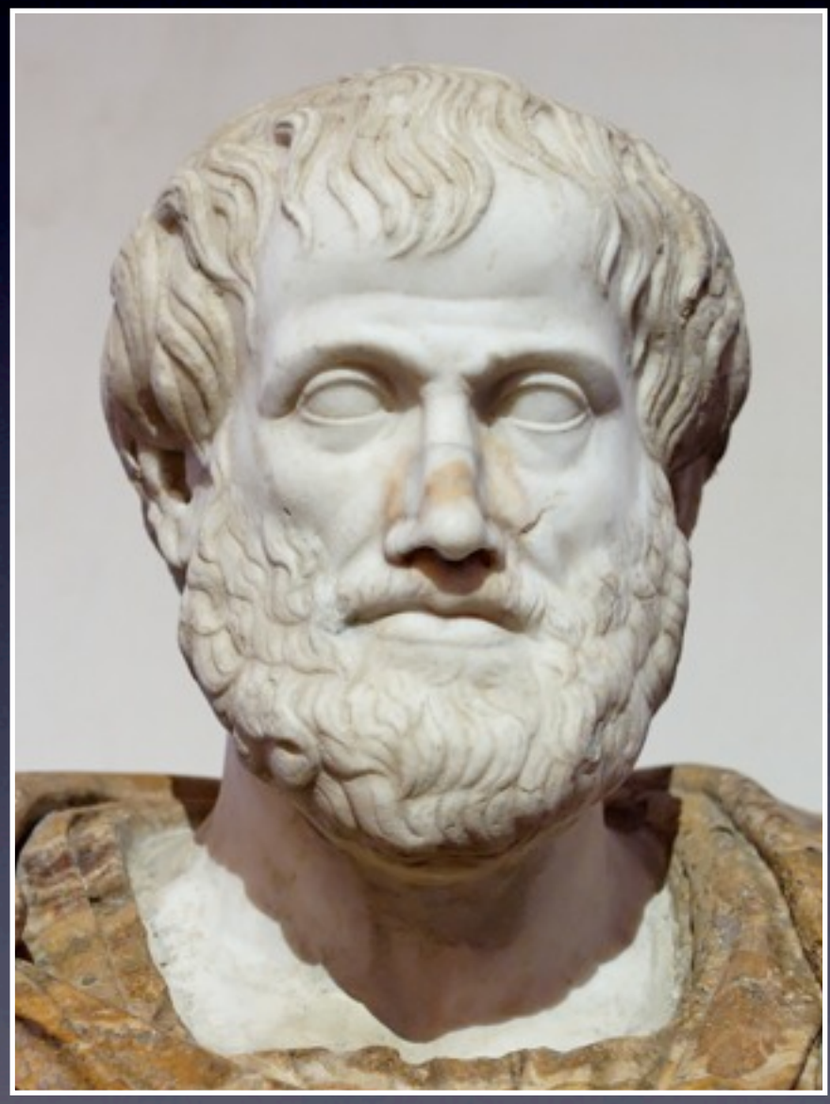
Two Meanings

- Ontological: Parsimony is a feature of nature. Nature chooses the simplest course
- Epistemological: Parsimony is a feature of science. Scientists should choose the simplest theory that fits the data.

Aristotle

- „We may assume the superiority ceteris paribus of the demonstration which derives from fewer postulates or hypotheses“

- „The principles should, in fact, be as few as possible,…“



C. Ptolemy

(in Almagest) used parsimony to help decide between theories of planetary motion.

Thomas Aquinas

- „If a thing can be adequately done by means of one, it is superfluous to do it by means of several.“

- „[…] we observe that nature does not employ two instruments where one suffices.“

R. Grosseteste

emphasised parsimony and held it as a real objective principle of nature, rather than a criterion of good explanations.

William of Ockham

- „Plurality is not to be posed without necessity“
- „What can be explained by the assumption of fewer things is vainly explained by the assumption of more things“
- „Entities must not be multiplied without necessity“ (not by W.O.)

Ockham‘s Demands

- „Everyone who makes a statement must have a *significant reason* for its truth“
  - Observation of a fact
  - Immediate logical insight
  - Devine revelation
- Experience justifies plurality, yet „one should not complicate explanations where simple ones will suffice.“

Ockham‘s View

- Epistemological principle (in contrast to Grosseteste or his teacher J. Duns Scotus)
- „To insist that nature always follows the simplest path is to limit God‘s power.“
- Shifted simplicity from nature to the theories formulated about it.

Example: Ockham

- Rejected impetus theory of motion
- „Motion is neither a separate thing nor a property of a thing, but rather a modification of existing things, namely, a change of location over time.“
- Lead to 17th century theory of impulse

Example: Copernicus

- Heliocentric cosmology based on parsimony arguments rather than measurements
  - Less cycles and epicycles
  - Unified parameters
- Only Bessel (parallax measurement) a century later provided convincing data

Counterexample: Galileo

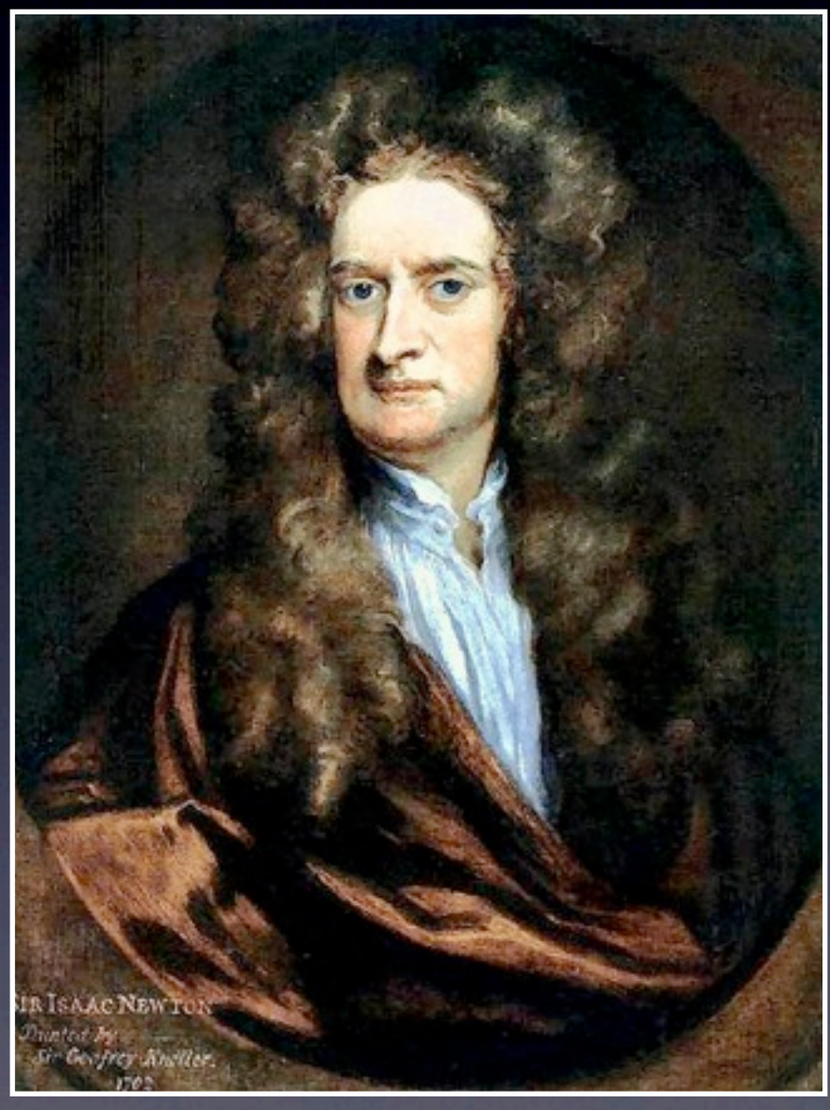
- Unified Aristotle (circular and rectilinear motion) to only circular motion
- Rectilinear motion is an illusion: Straight trajectories observed from off the earth are in fact curved.
- Underlying thinking of one unified theory of motion was correct, though (Einstein).

I. Newton

- In *Philosophiae Naturalis Principia Mathematica*

1. Parsimony in an ontological sense

2. Parsimony in an epistemological sense



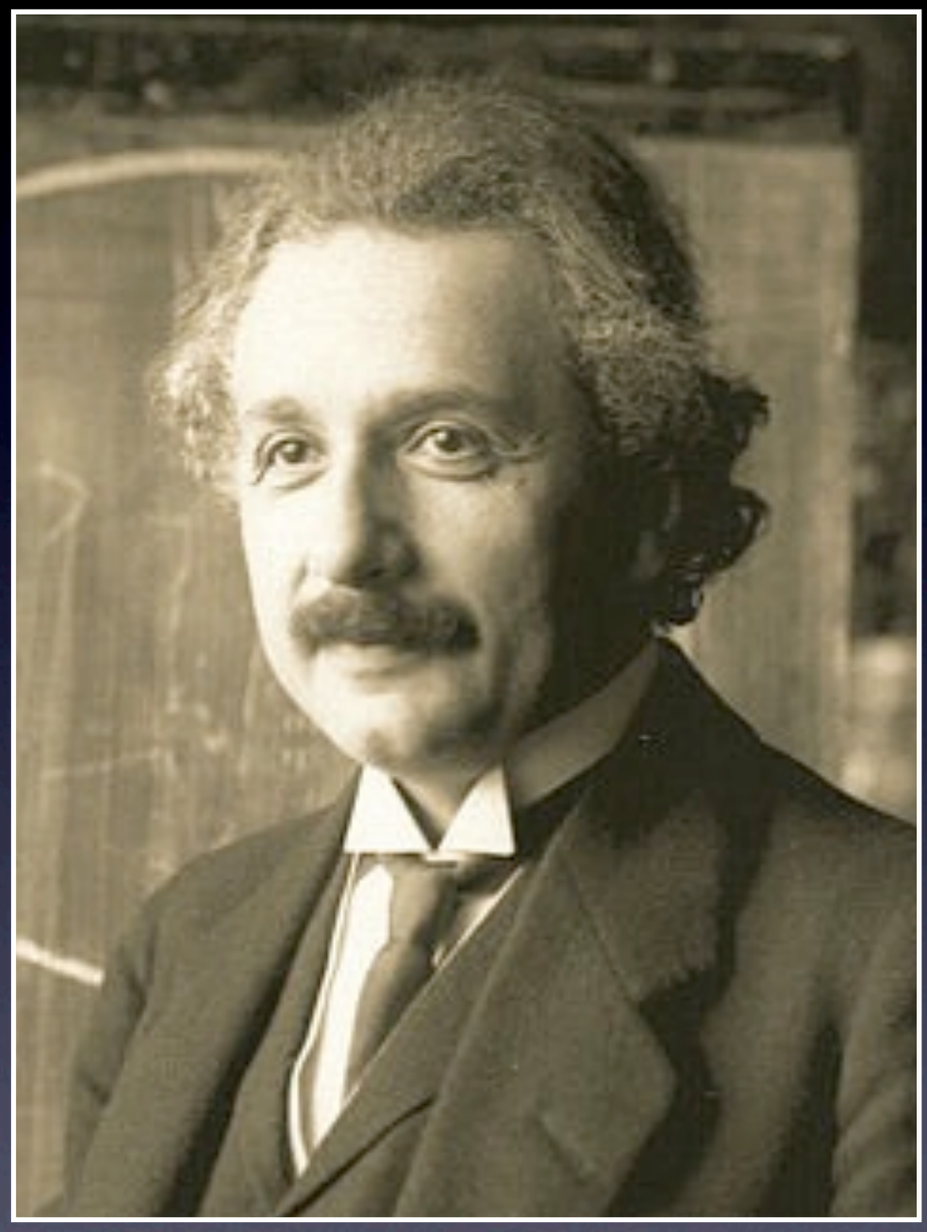
G. W. Leibniz

proved that the path of a light ray minimised the path difficulty (geometric length times resistance of the medium).

A. Einstein

„God would not have passed up the opportunity to make nature that simple.“ (gRT)

„Everything should be made as simple as possible but not simpler.“



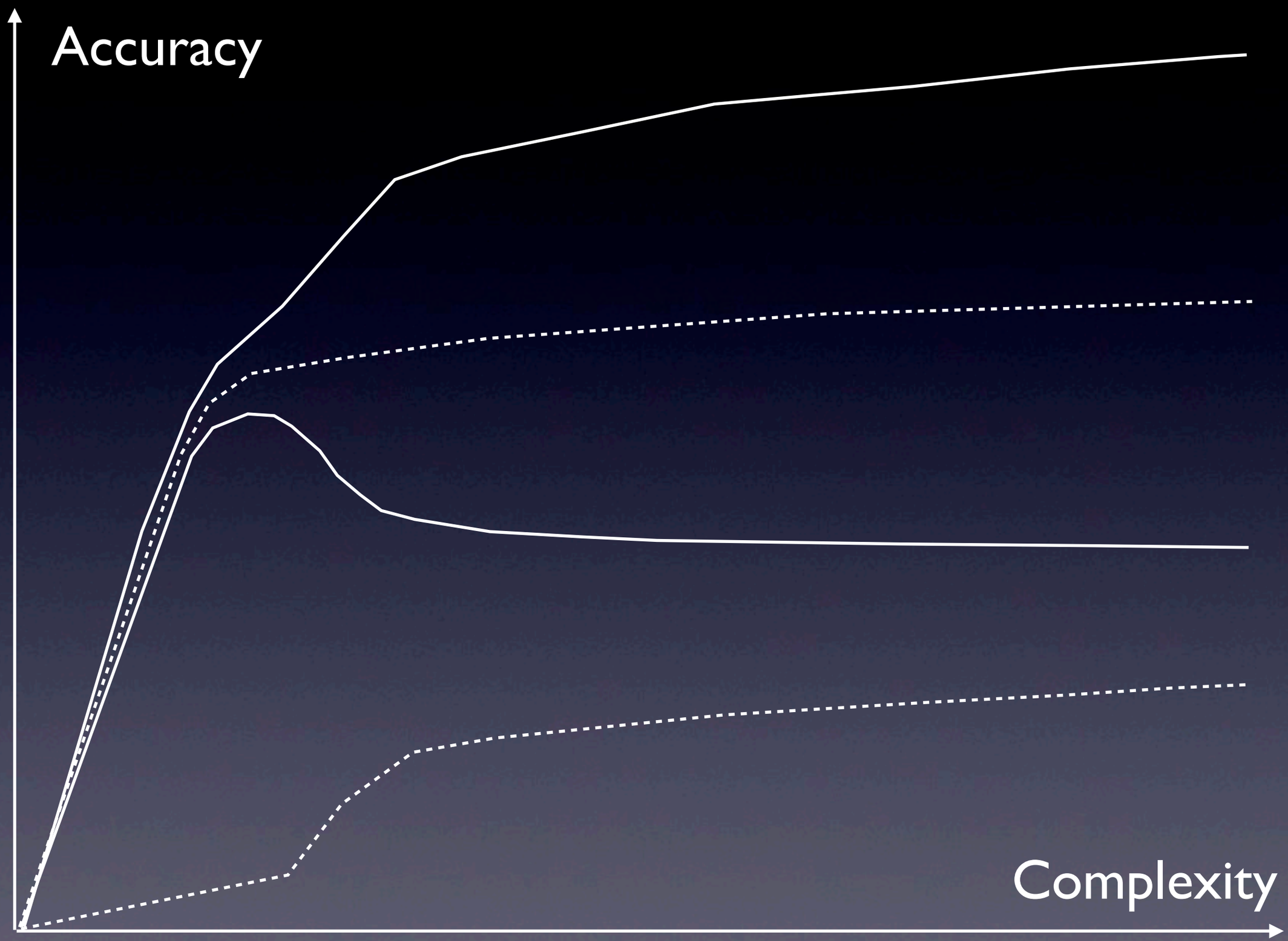
More recently…

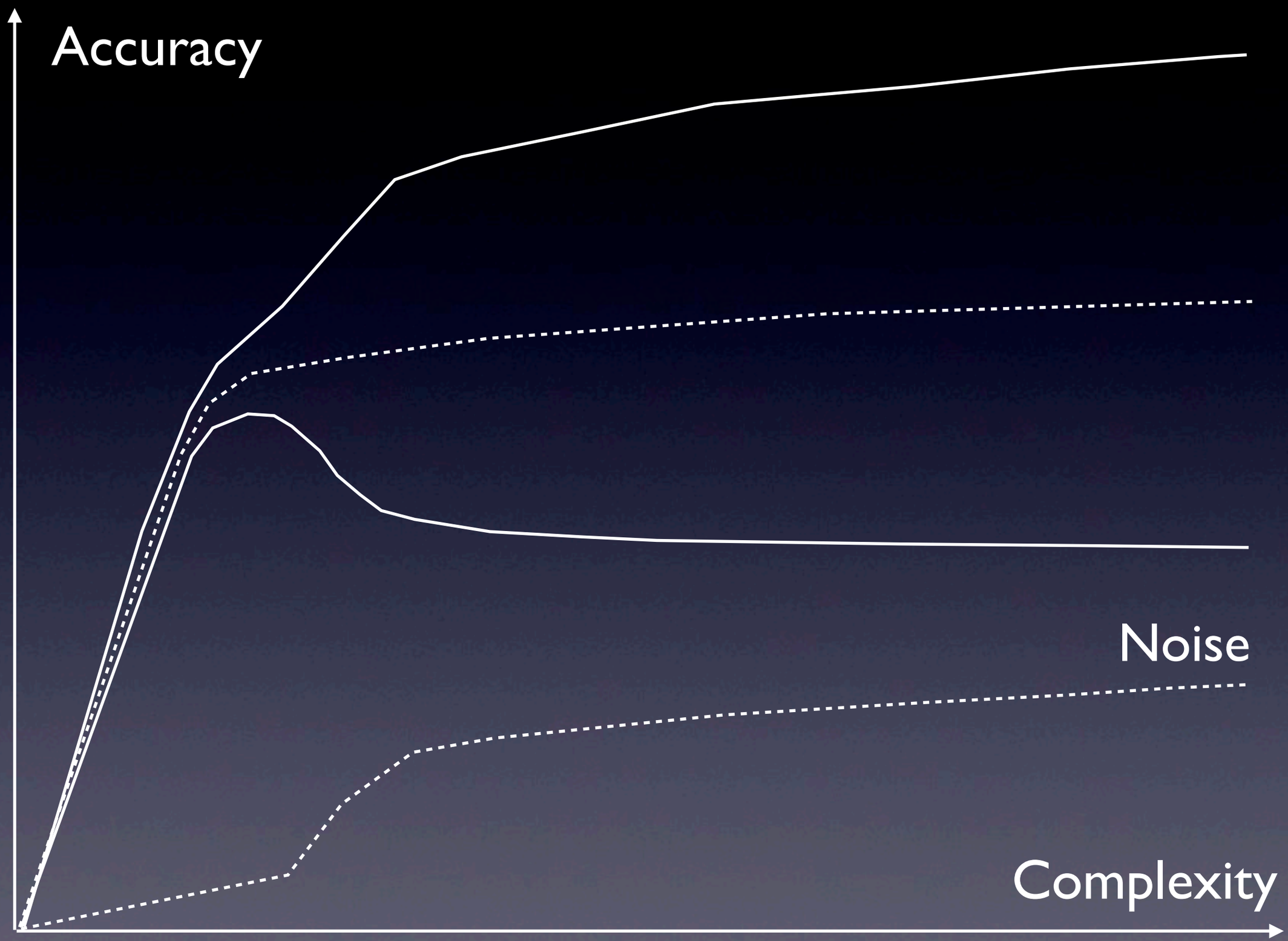
- Statisticians show:
  - Simple theories tend to make reliable predictions.
  - Parsimony yields considerable gain in accuracy and efficiency.

History: Summary

- Many paradigm shifts precipitated by parsimony rather than by better fit.
- False theories rather get into trouble with parsimony than measurements.
- Lesson: Scientists who also consider parsimony, not just the data, are often those on the cutting edge.

Principles & Example


Accuracy
Complexity


Accuracy
Noise
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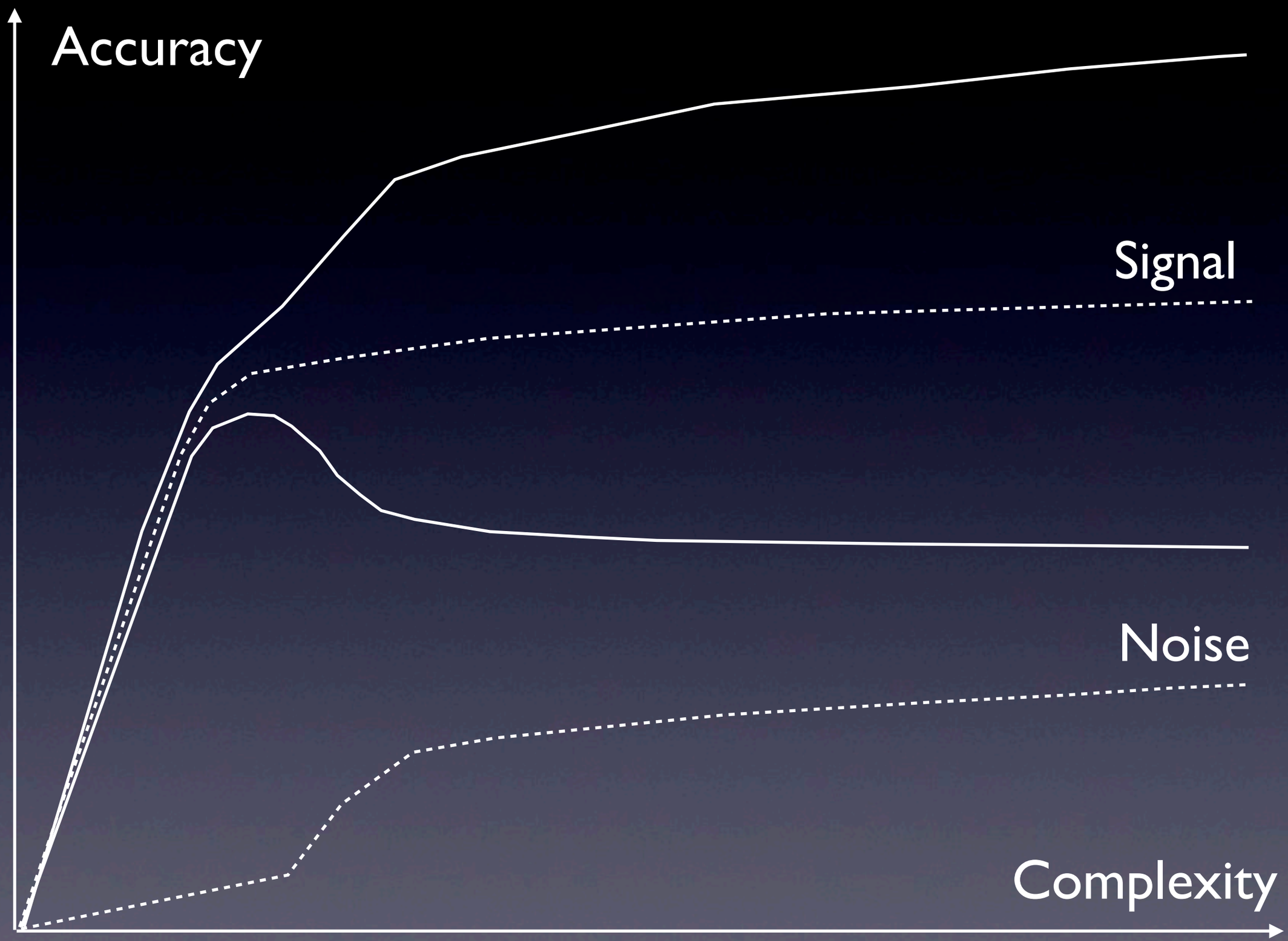
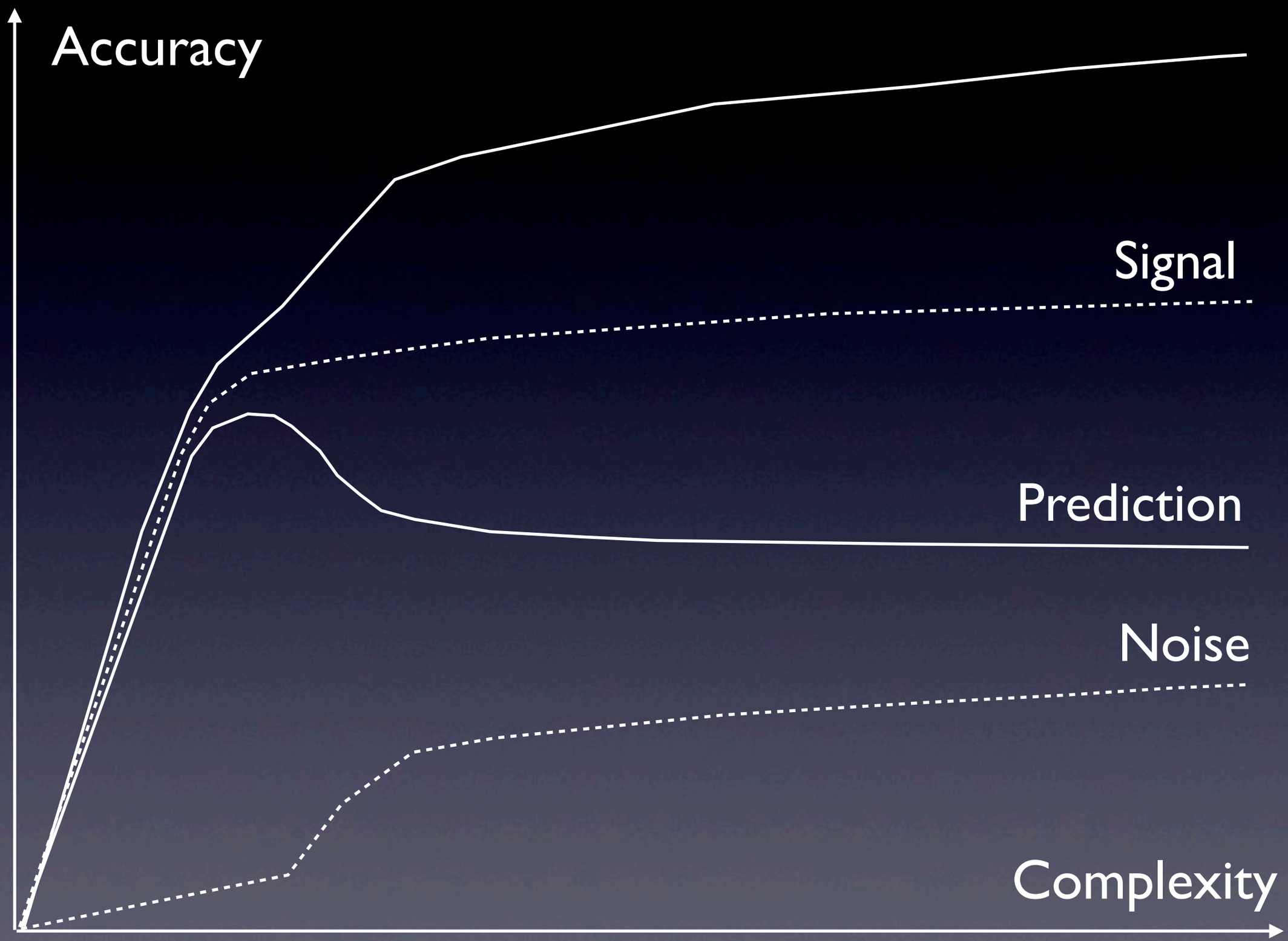

Accuracy
Signal
Noise
Complexity


Accuracy
Signal
Prediction
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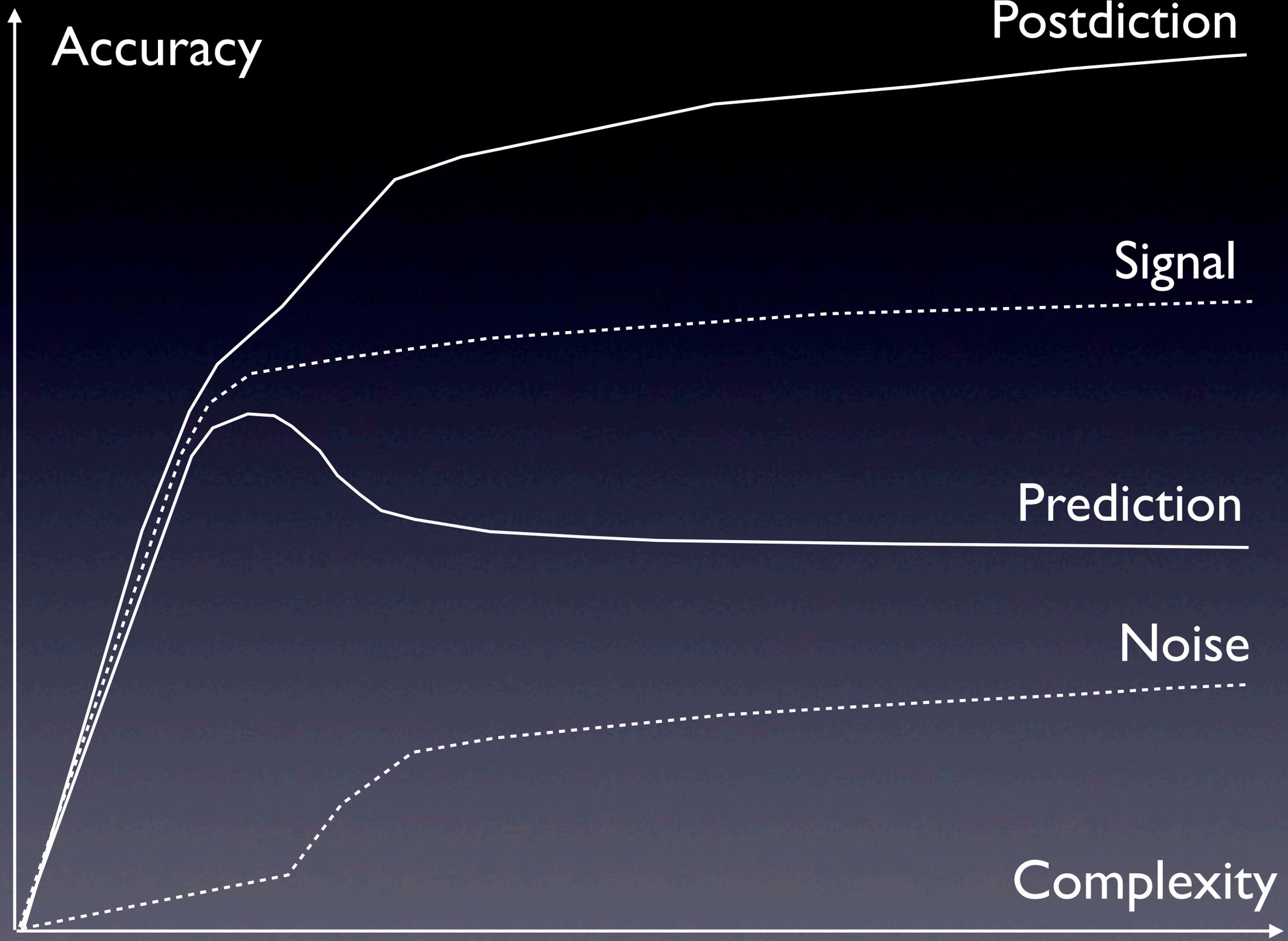
Accuracy
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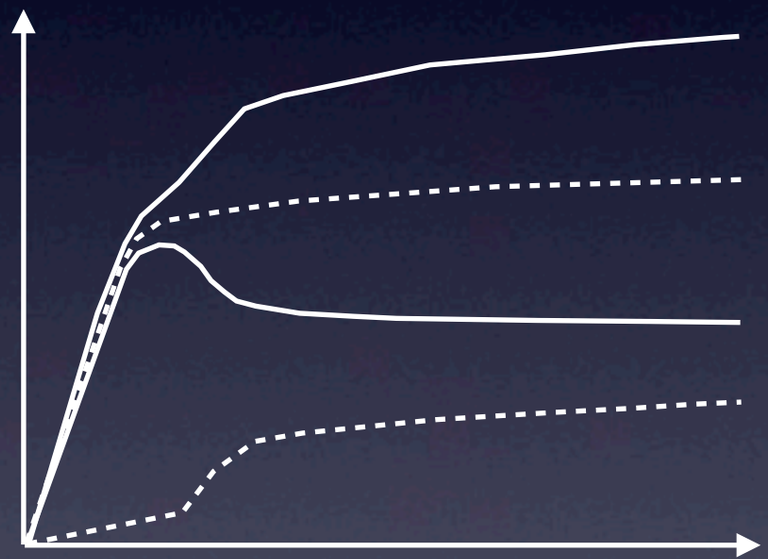
Principles

- Signal and Noise
- Population and Sample
- Prediction & Postdiction
- The Curve-Fitting Problem
- Related Data
- Statistical Tools



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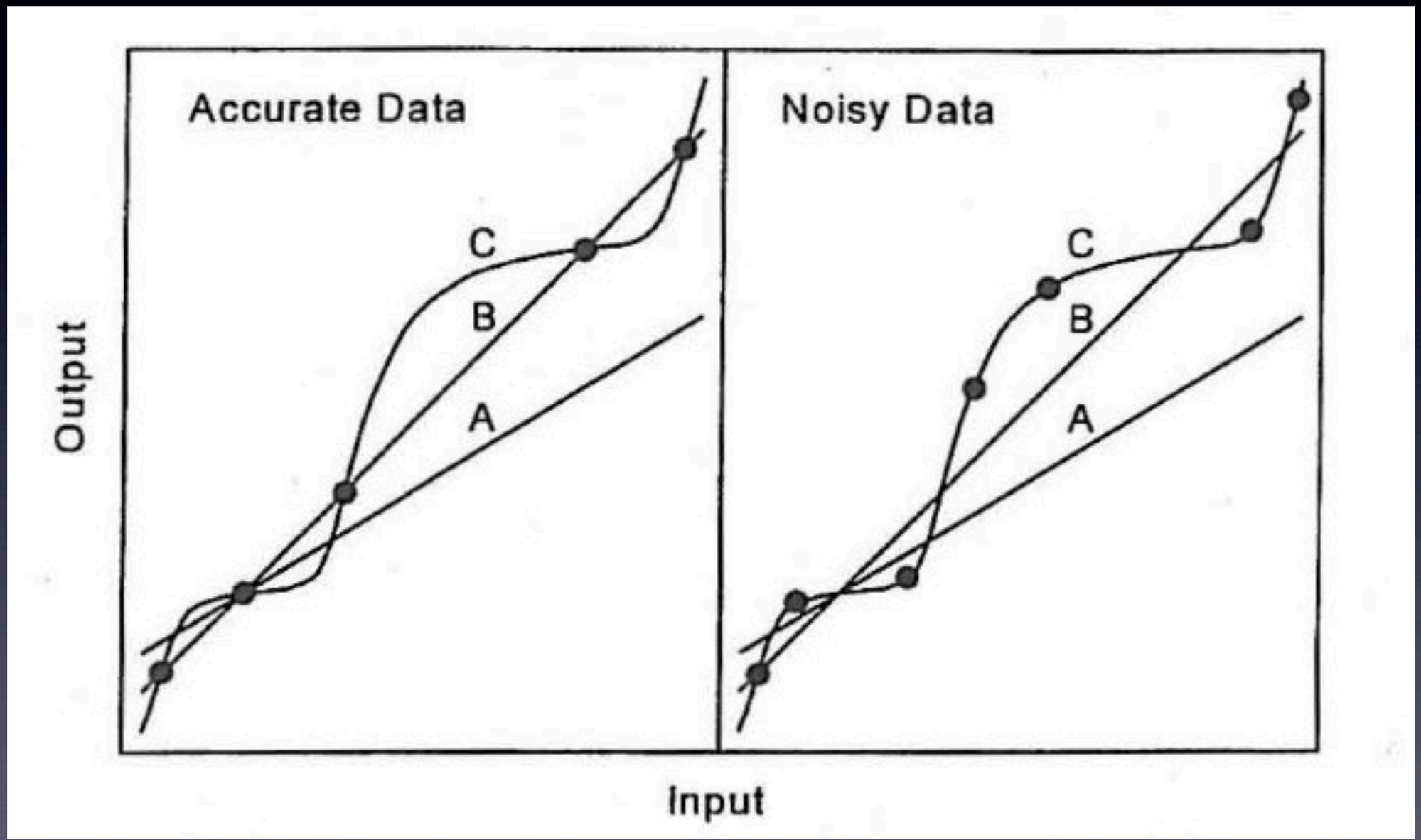

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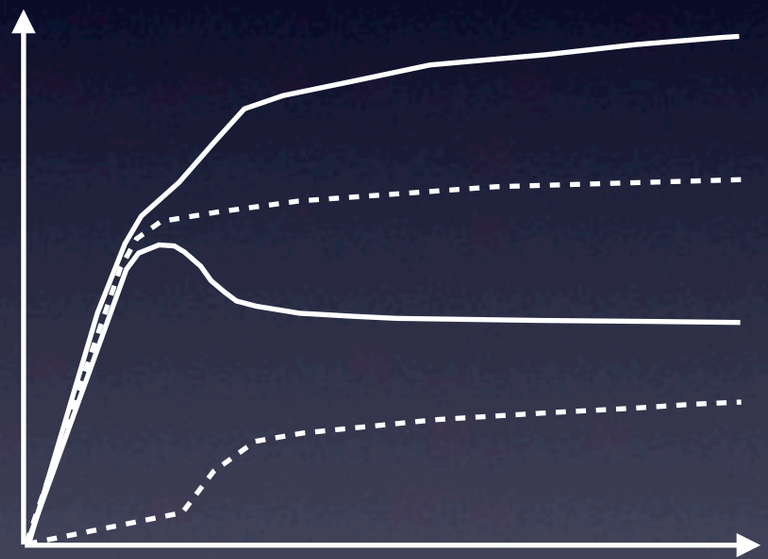


Ex: Genetics (G. Mendel)

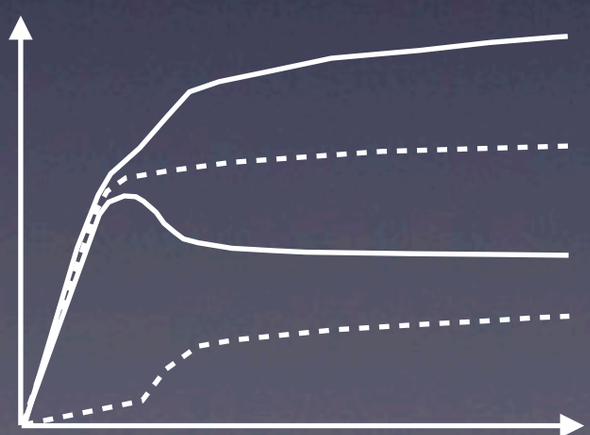
- Discovered ratios between *dominant* and *recessive* properties in peas passed on through generations

- Two parsimony arguments
  - Combination of *seven* different trails postulating an underlying phenomenon
  - Ratio should be small *integers* → 3:1

Philosophic Perspective

Parsimony/Accuracy Trade-Off

- Combining simplicity with a ceteris paribus clause about an equally accurate fit to the data
- How to find a suitable balance?
- Almost always prediction is relevant.
  - Pick the model at the top of Ockham‘s hill



Prediction & Truth

- Predictive success is often taken as evidence of truth.
- Historic example: Halley‘s comet
- Problem: predictive accuracy tends to be associated with truth.

Parsimony & Nature

- Epistemological parsimony implicitly accepts that nature is simple.
- „Were nature not simple, science would loose all its foundational principles at once.“
- „The beginning of science‘s simplicity is simple questions.“

Ockham‘s Razor

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