# Introductory thoughts on modelling - Day 1

## CoSMo 2017
## Gunnar Blohm

# The 5-day intro program

- Day 1: Overview
  - Philosophy of science (Gunnar)
  - What is modelling / objective functions (Konrad)
  - Sensory-motor control @ CoSMo (Gunnar)
  - Paper writing 101 (Konrad) – before dinner
  - Tutorials
    - Basic data plotting & tuning curves (Konrad)
    - Gain fields as a canonical computation for reference frame transformations (Gunnar)
- Day 2: Bayesian approaches
  - Bayesian basics & cue combination (Konrad)
  - Advanced Bayes & time series (Paul)
  - How-to-model (Gunnar, Konrad, Paul) – before dinner
  - Tutorials
    - Cue combination

# The 5-day intro program

- Day 3: Linear systems
  - Theory (Gunnar)
  - Kalman filter application (Paul)
  - Modelling eye movements (Gunnar)
  - <span style="color:red">Grant writing 101 (Konrad) – before dinner</span>
  - <span style="color:green">Tutorials</span>
    - <span style="color:green">Modelling saccades (Gunnar)</span>
    - <span style="color:green">Kalman filters for trans-saccadic memory (Paul)</span>
- Day 4: Optimal Feedback Control
  - Brute force control (Konrad)
  - Optimal Control (Gunnar)
  - PID control (Paul)
  - Optimal feedback control (Gunnar, Paul, Konrad)
  - <span style="color:green">Tutorials</span>
    - <span style="color:green">Inverted pendulum (Gunnar, Paul, Konrad)</span>
    - <span style="color:green">OFC (Gunnar, Konrad, Paul)</span>

# The 5-day intro program

- ▸ **Day 5: Optimality and data analyses**
  - ▸ Naïve Bayesian decoding (Konrad)
  - ▸ Model fitting (Konrad & Luigi)
  - ▸ Model evaluation (Gunnar)
  - ▸ Analyzing microchip data – limitations of current methods (Konrad)
  - ▸ Tutorials
    - ▸ Basic data fitting (Konrad)
    - ▸ Advanced data fitting (Luigi)

# Knowledge acquisition

‣ **Knowledge acquisition attempts to describe what's true, real**

   ‣ But what is "reality"?

   ‣ "What is real? How do you define real? If you're talking about what you can feel, what you can smell, what you can taste and see, then real is simply electrical signals interpreted by your brain. This is the world that you know."

   ‣ Morpheus's answer to Neo in *The Matrix*, 1999

   ‣ http://www.youtube.com/watch?v=WnEYHQ9dscY

   ‣ "You assume it is what you see, hear, touch, taste and smell - but is this assumption justified?"

   ‣ From *Dark Star – The spaced-out space ship, 1974*

   ‣ http://www.youtube.com/watch?v=qjGRySVyTDk

# Reality - an old question…

▸ Plato (~423-348 BC)

  ▸ Allegory of the Cave: "The prison-house is the world  of sight."
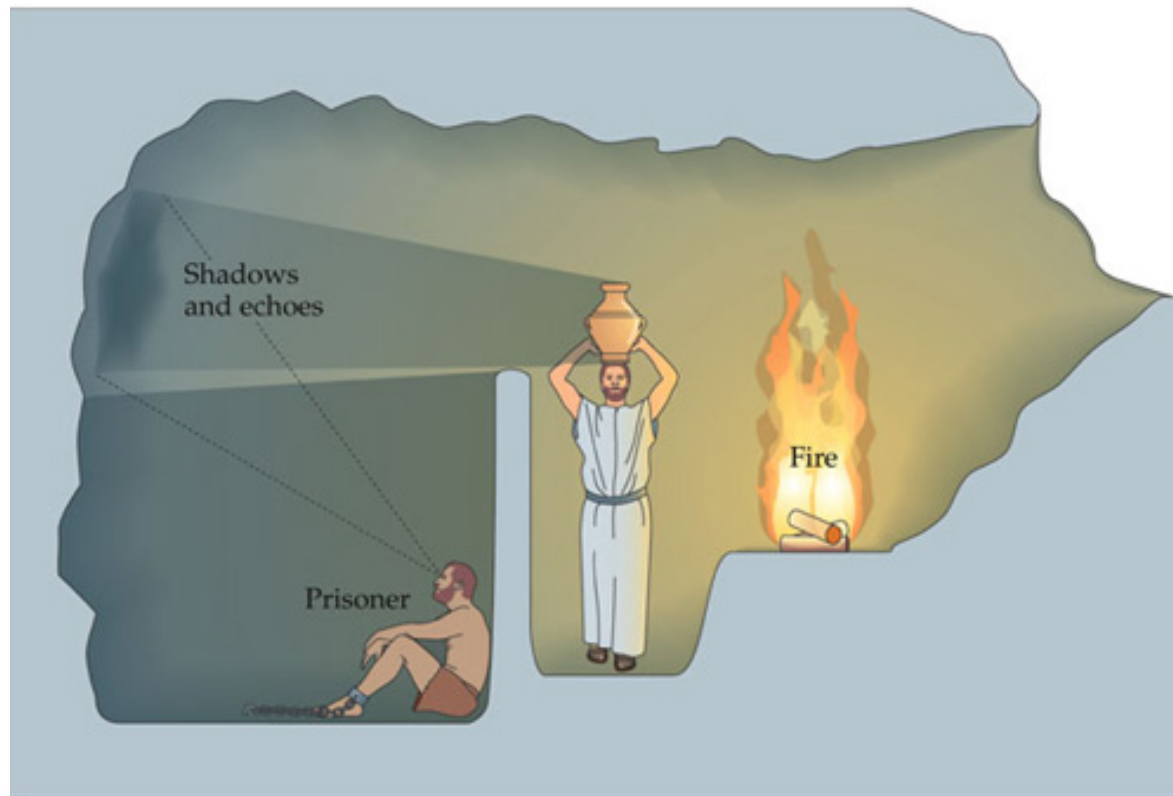
Raphael (1509-1511)

# Reality - an old question...

▸ ## David Hume (1711-1776)

  ▸ There seems to be a contradiction between the subjective experience of direct perception and the fact that all we have is some very limited measurements.

  ▸ Hume's suggestion: Perceived reality is reliable and that is all that counts. Whether it is valid as well, we don't know.

  ▸ And there is no way to find out

  ▸ This is problematic: phantom limbs, illusory smell, etc. Or NOT???

Allan Ramsay (1766)
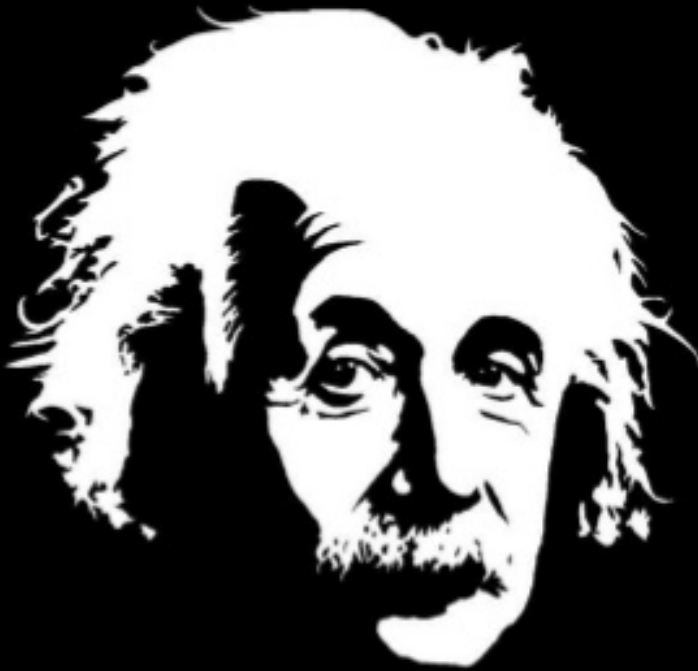
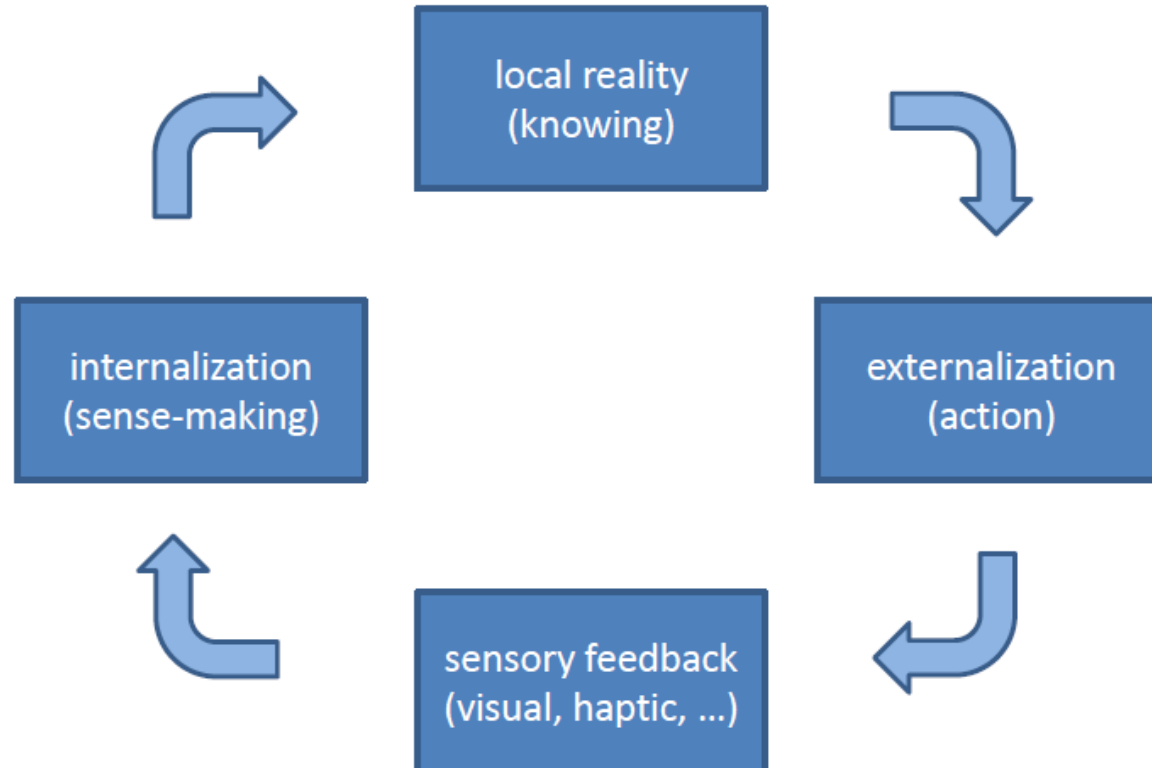"Reality is merely an illusion, albeit a very persistent one."
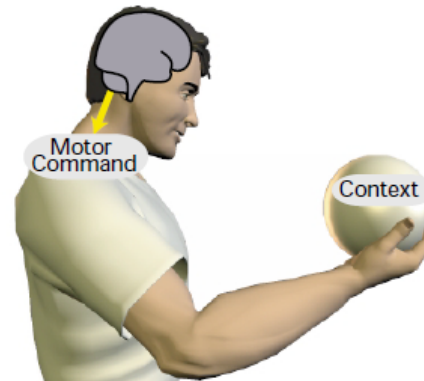
~ Albert Einstein

# Why does this matter?

- We are trying to model the brain!

- But: The brain is trying to infer "reality" from sensory measurements
  - Thus the brain tries to model reality!!!

- Therefore, modelling the brain comes down to model the "model of reality"…
  - i.e. the brain is an inference machine
  - Additional constraint: It's purpose is to generate actions!
  - The inferences can sometimes be wrong, e.g. illusions

# Constructivist worldview (≠ objectivism)

- Realities are local and specific to each individual
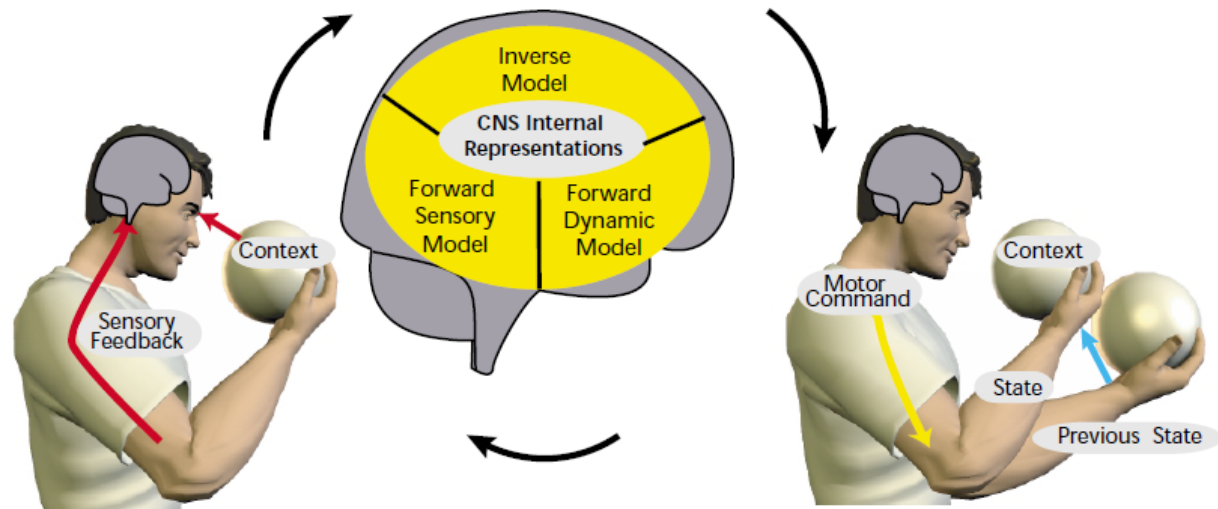- Constructions (models) are not true or false, but rather more or less informed / sophisticated

# Constructivist worldview

Wolpert & Ghahramani (2000)
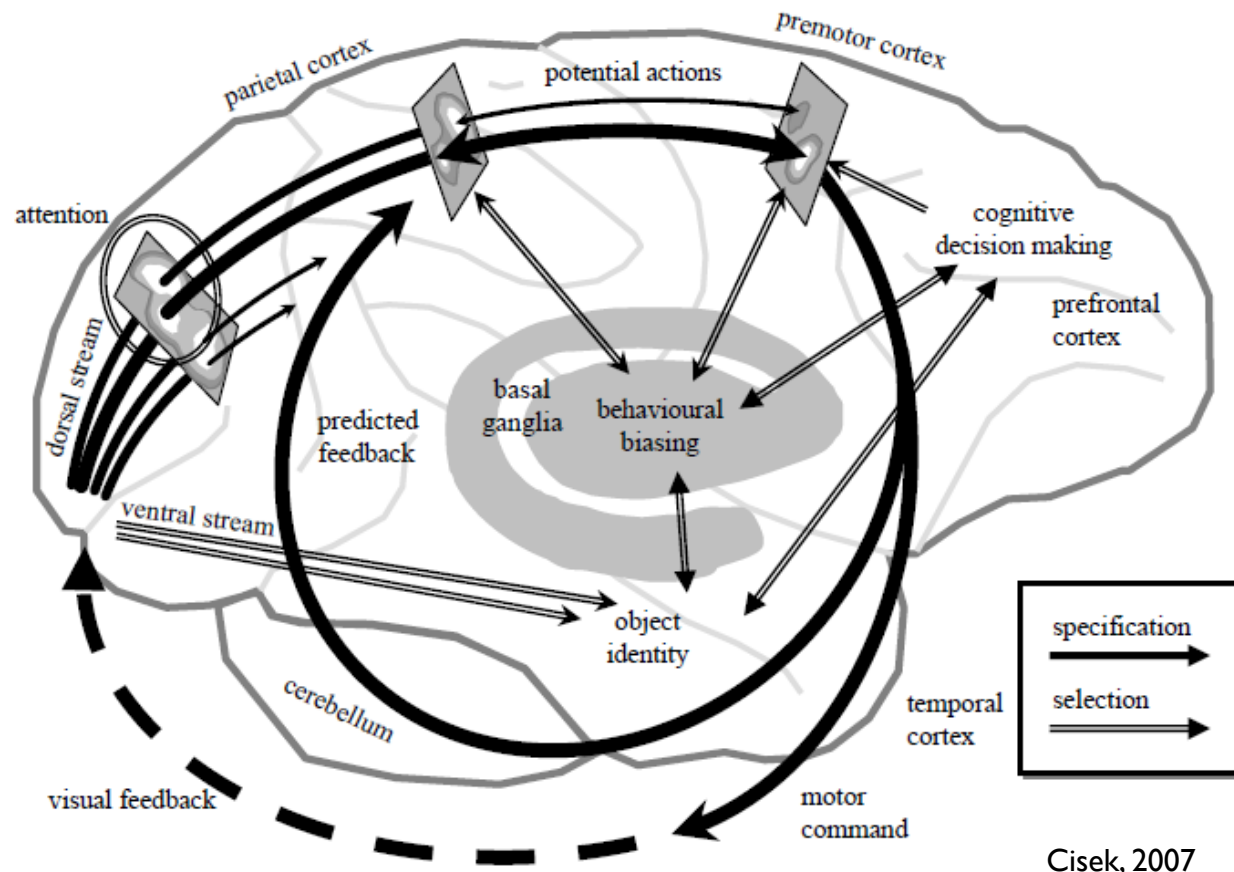
[task, state, context] ⟶ motor command

Inverse Model

CNS Internal Representations

Forward Sensory Model

Forward Dynamic Model

Motor Command

Context

Sensory Feedback

State

Previous State

[state, motor command, context] ⟶ sensory feedback

[previous state, motor command, context] ⟶ state

# Constructivist worldview

▸ ## Affordance competition model



Cisek, 2007

# So then, what can we know / learn?

▸ Epistemology (Greek: "knowledge") studies the nature of knowledge, the rationality of belief, and justification.

  ▸ Knowledge is summarized in "models"

  ▸ Models ≠ reality

  ▸ Models = working hypotheses

  ▸ By definition, all models are wrong… otherwise they would be reality.

  ▸ Models = simplification, abstraction, condensate
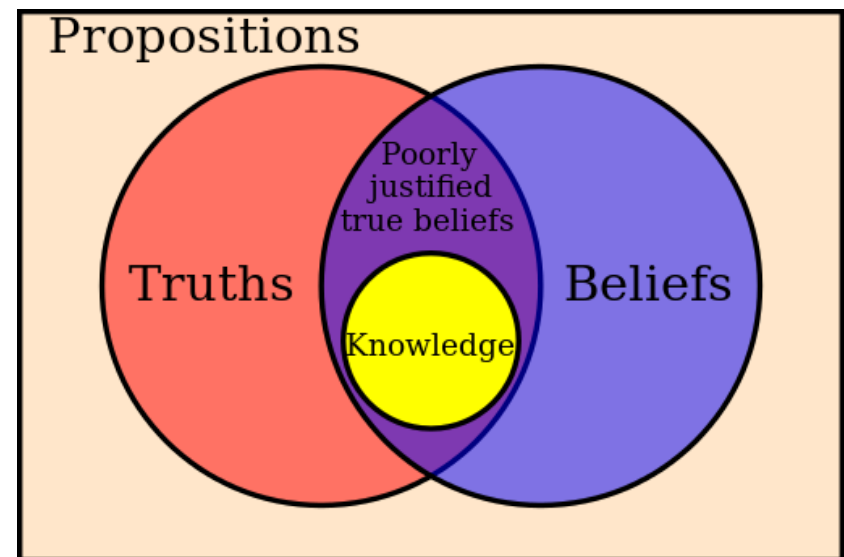
# So then, what can we know / learn?

▸ **But models can be very powerful, if they**

  ▸ Capture general principles

  ▸ Advance our mechanistic understanding (beyond what's directly observable!)

  ▸ Make testable predictions, i.e. reduce the space of potential answers to a specific question

  ▸ Save animal lives (bc only a few experiments are needed)

  ▸ Generalize!

  ▸ Are falsifiable (Popper)

  ▸ Have a practical use (e.g. simulation of drug effects on behavior)

  ▸ …

# So then, what can we know / learn?

- Empirical falsification (Karl Popper, 1902-1994)

  - **Critical rationalism**: A theory in the empirical sciences can never be proven (no matter how many positive experimental outcomes), but it can be falsified, meaning that it can and should be scrutinized by decisive experiments

  - **If** "T" is false, **then** (in principle), "T" could be *shown to be* false, by observation or by experiment

  - If the outcome of an experiment contradicts the theory, one should refrain from *ad hoc* manoeuvres that evade the contradiction merely by making it less falsifiable
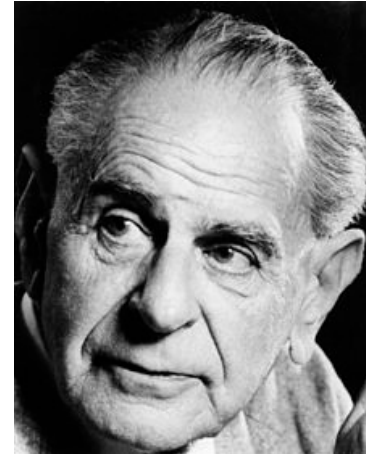
# So then, what can we know / learn?



- ► Empirical falsification (Karl Popper, 1902-1994)
  - ► A theory should be considered scientific if, and only if, it is falsifiable
  - ► Scientific theory, and human knowledge generally, is irreducibly conjectural or hypothetical
- ► How then is scientific progress made?
  - ► $PS_1 \rightarrow TT_1 \rightarrow EE_1 \rightarrow PS_2$
    - □ PS: problem situation
    - □ TT: tentative theory
    - □ EE: error elimination
  - ► Theories that better survive the process of refutation are not more true, but rather, more "fit" – i.e., more applicable to a given problem situation

REALITY is a STATE of MIND

KA
Oct 2006

If you are wrong
you were right