

# **An introduction to Reinforcement Learning**

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# What is reinforcement learning (RL)?

Also, why are slides in English?

- RL is a **computational approach** to learning from **interactions** with the **environment**
  - Trial-and-error
  - Delayed reward
- Considers whole problem of **goal-directed** agent interacting with an **uncertain** environment
- RL agents
  - Have explicit goals
  - Sense aspects of their environments
  - Choose actions to influence their environments
- Very general

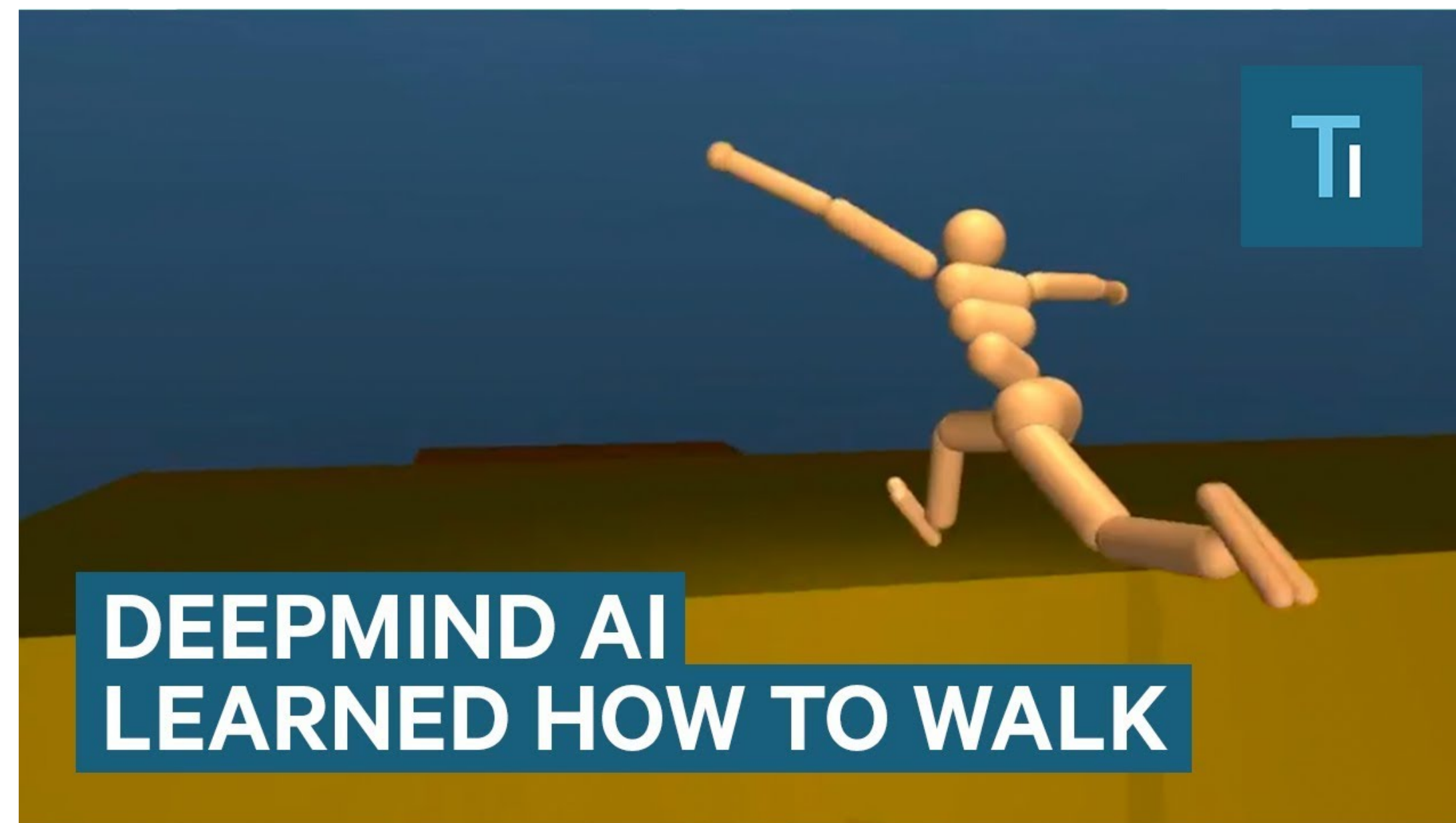
# What is reinforcement learning (RL)?

A few hours (+a bit of evolution) after birth:



# What is reinforcement learning (RL)?

This process is perhaps not too different from AI learning to walk:



# What is reinforcement learning (RL)?

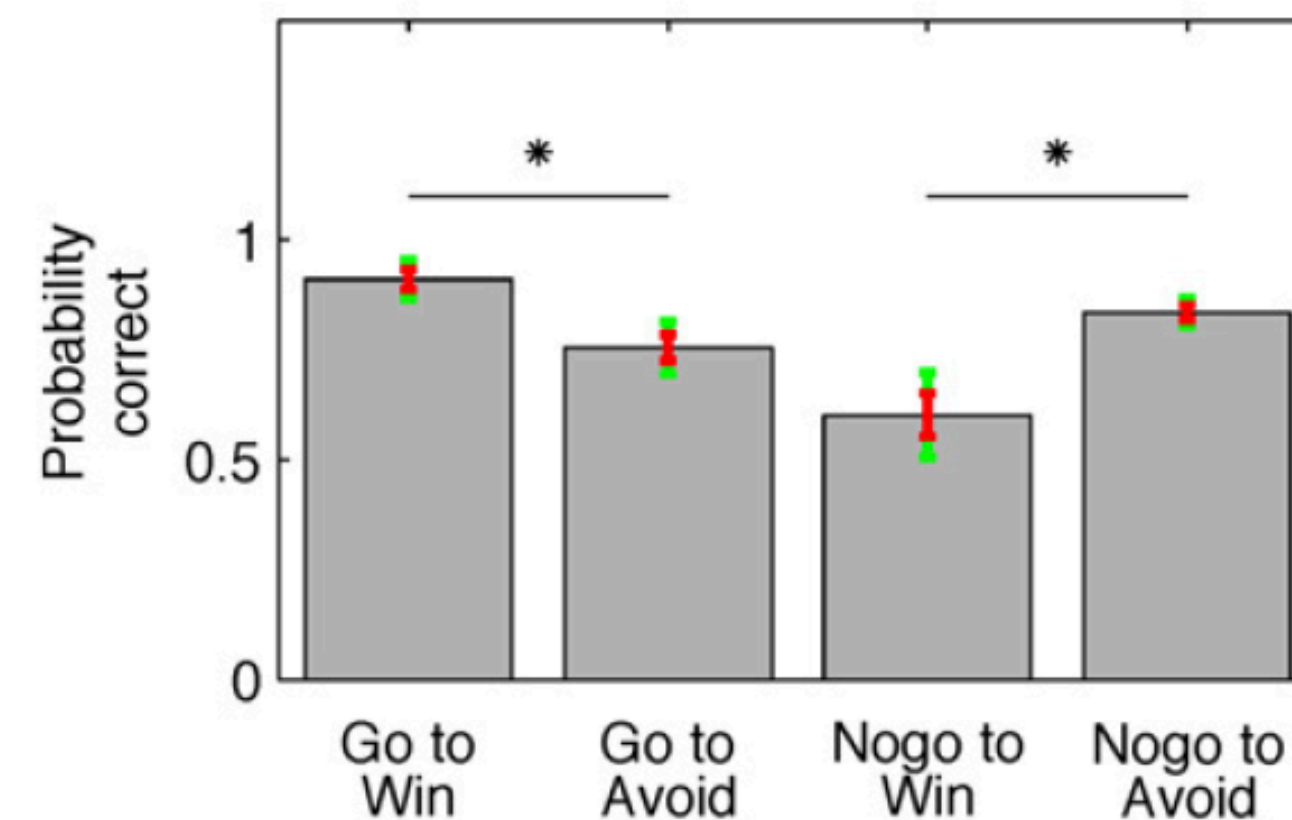
Learn useful actions:



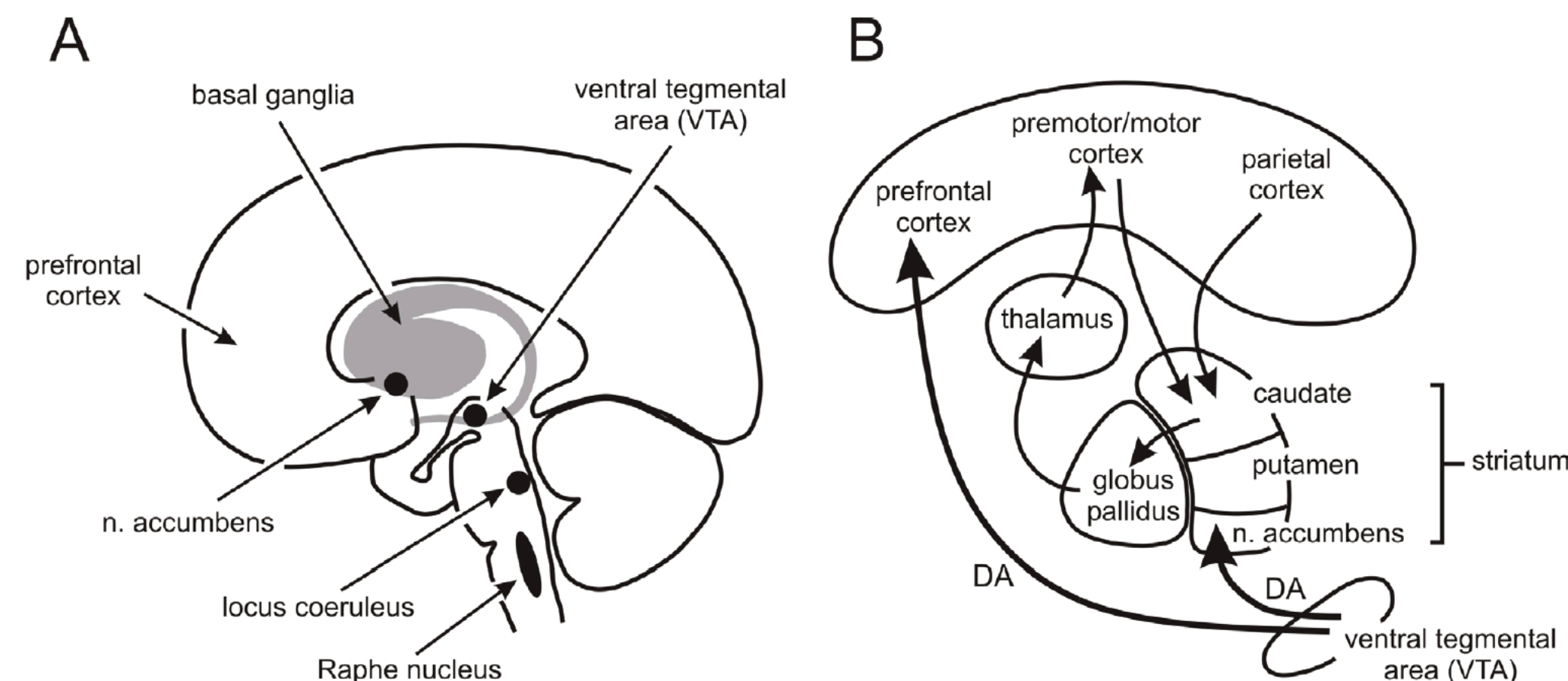


# What is reinforcement learning (RL)?

RL has been tremendously successful at explaining behaviour and psychological variables  
(More next session)



Guitart-Masip et al. 2011



RL has been tremendously successful at explaining neuroscience  
(More in session after next)

# Types of (machine) learning: supervised learning

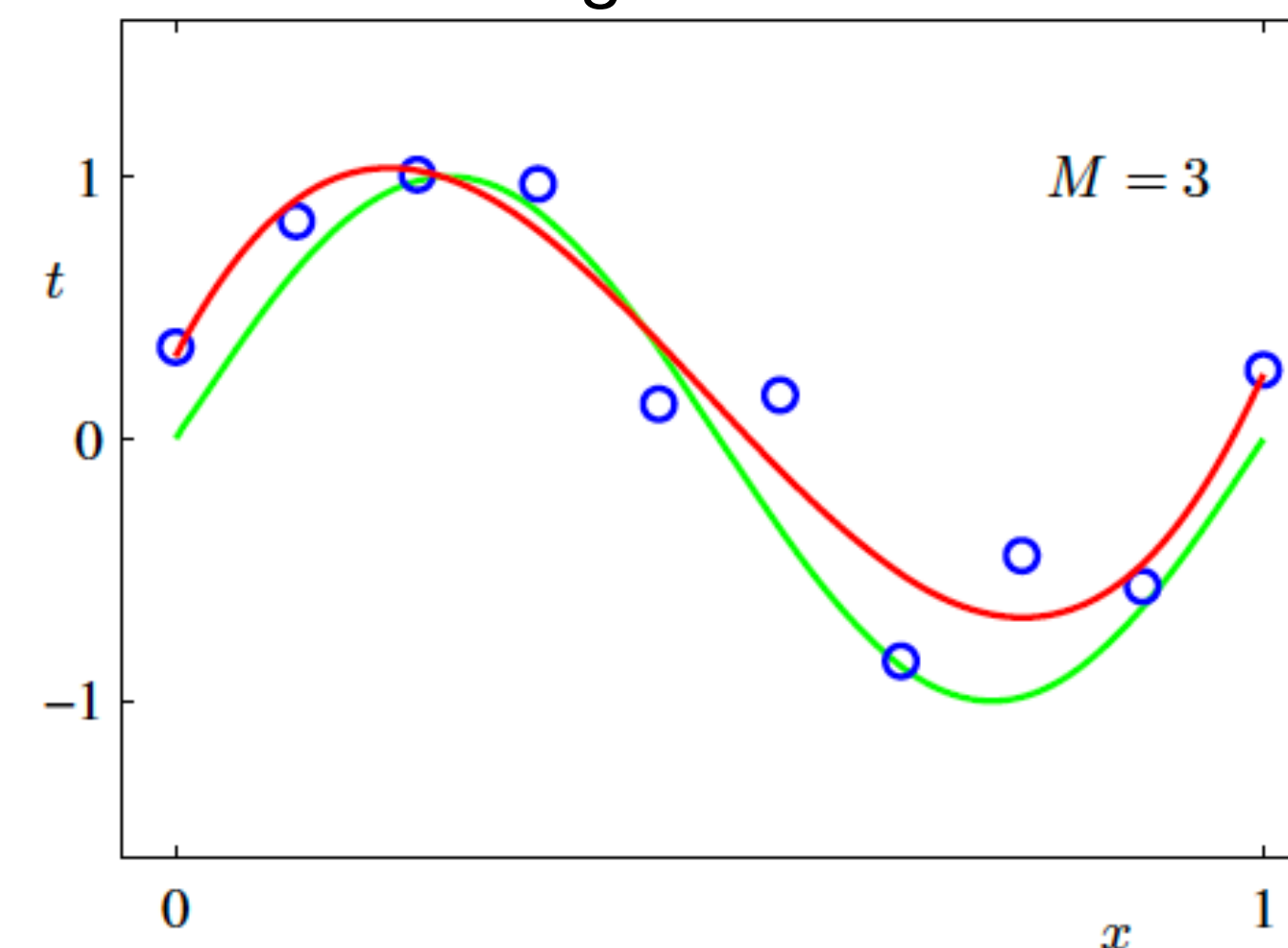
- Find correct labelling/prediction of data:

Classification



MNIST

Regression

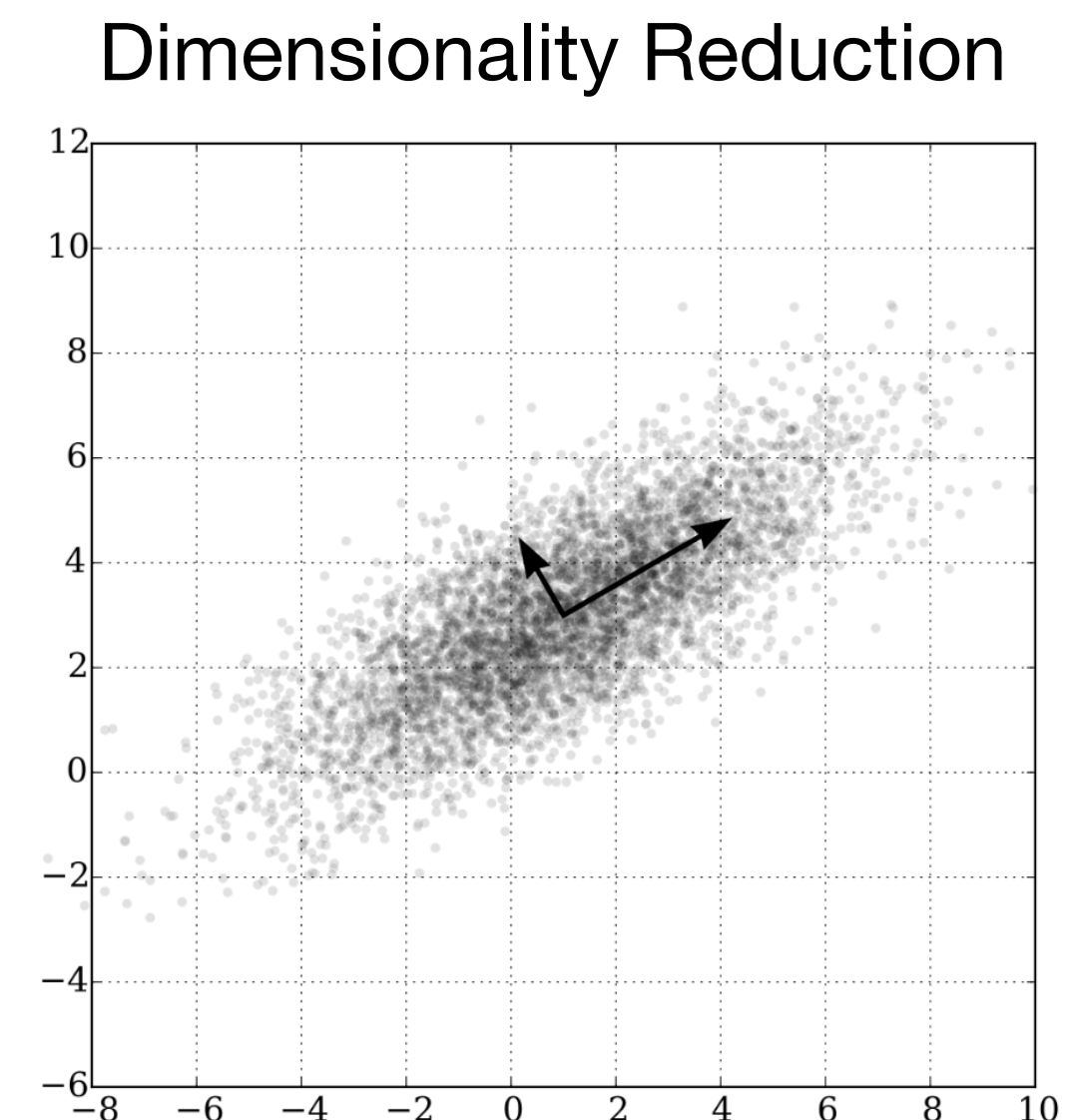
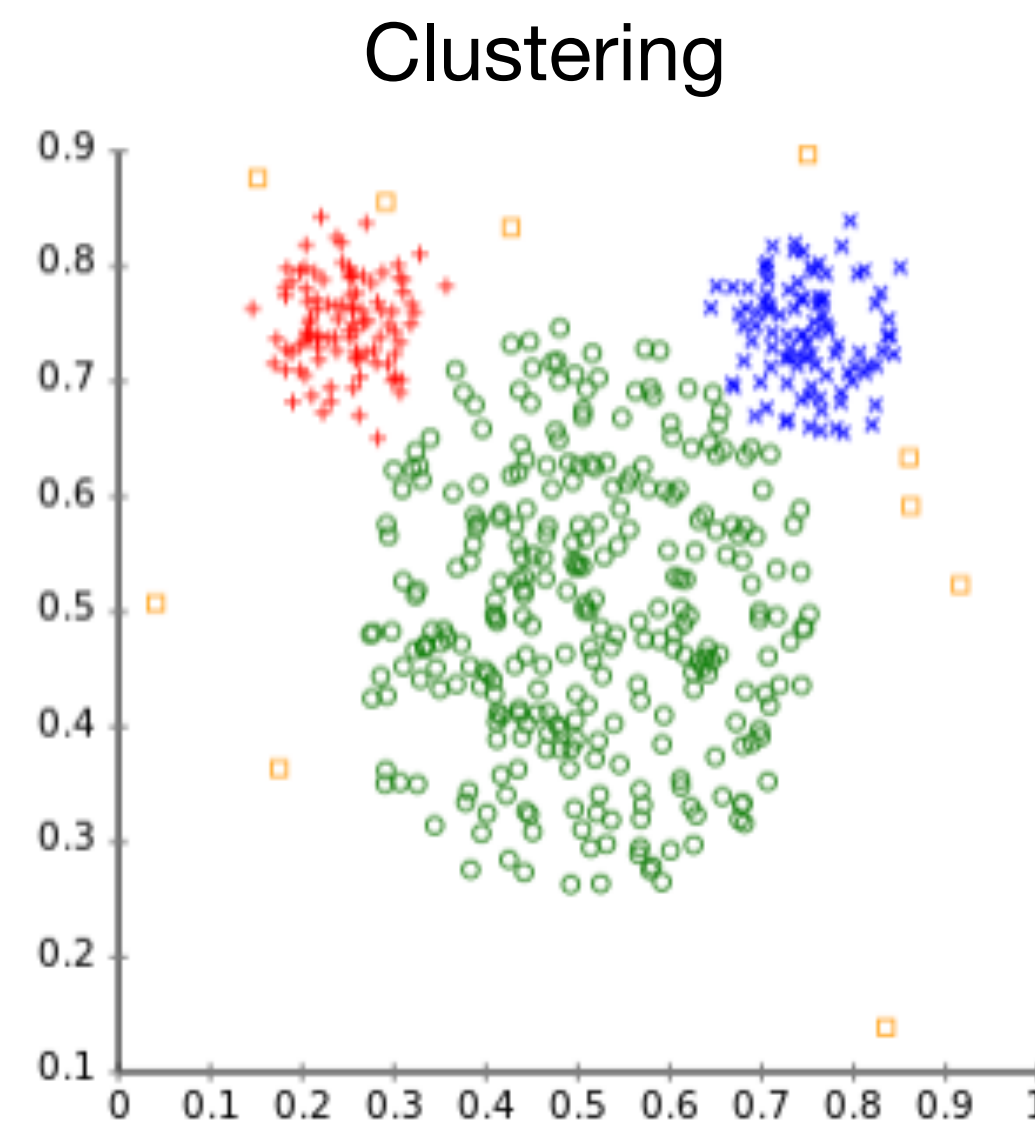


Bishop 2006

- That's not what we want though:
  - Want to learn from *own experience* by *interacting* with the world

# Types of (machine) learning: unsupervised learning

- Find structure in data:

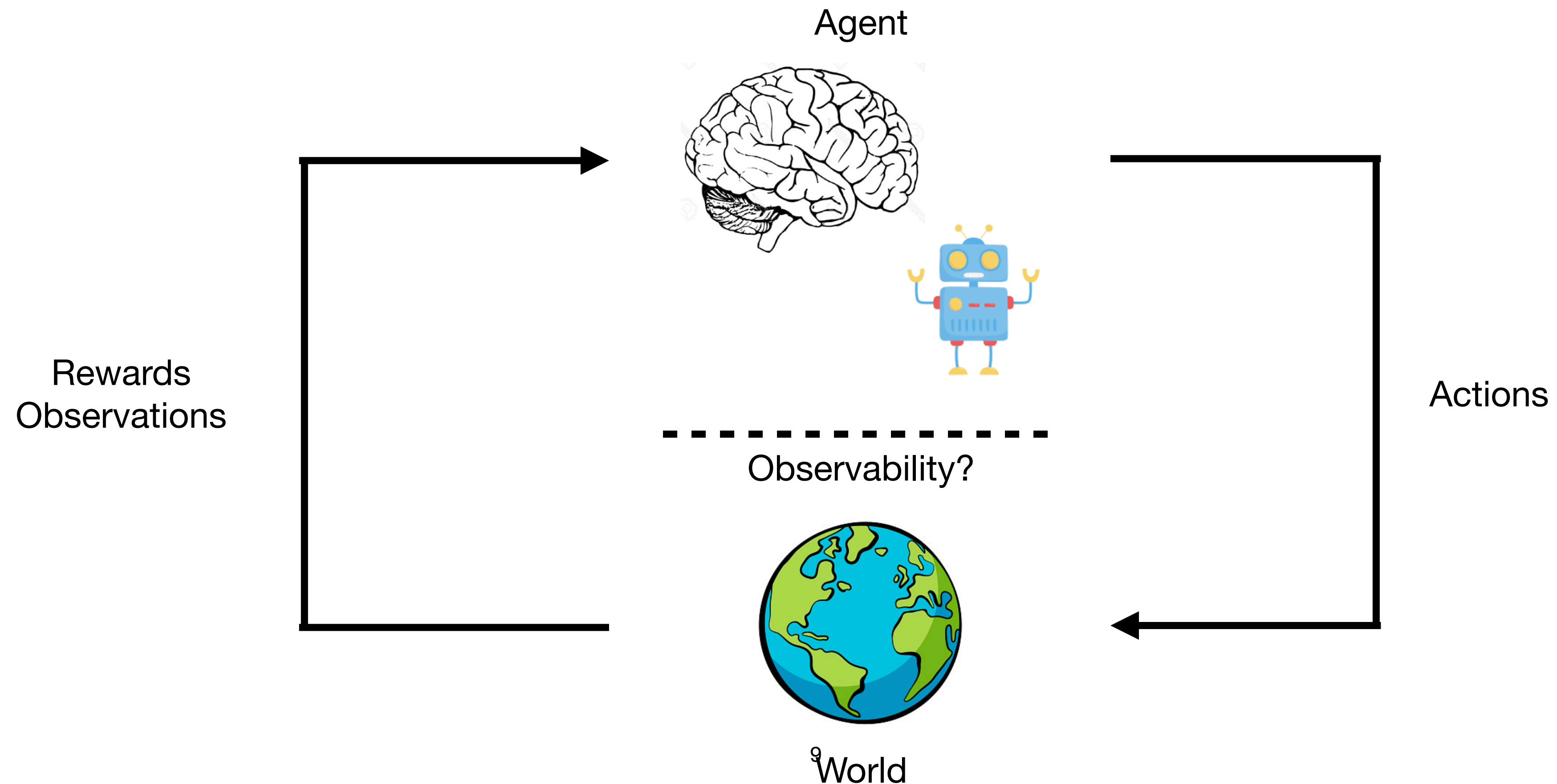


- That's also not what we want:
  - Don't (necessarily) want to learn hidden structure, rather: maximise reward



# Types of (machine) learning: Reinforcement learning

- In RL, we want to learn good actions from interactions with the world



# RL as a Marrian system?

- RL has the ambition to provide a complete account of agency
  - There is much debate about that (e.g. Sliver et al. 2021: “Reward is enough”)
- Can RL account for Marr’s levels?
  - The **problem**: optimal prediction of future reward
  - The **algorithm**: temporal difference learning, Q-learning, model-based RL, ...
  - Neural **implementation**: Basal ganglia, dopaminergic system, replay, ...

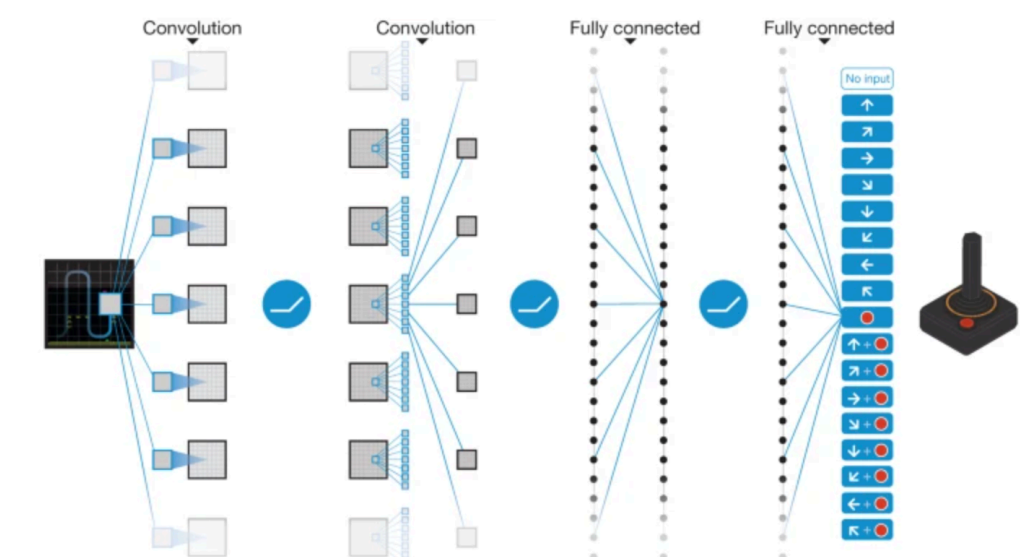
# Why should we know about RL?

- Lots of reasons
- Powerful framework to understand individual differences in behaviour - individual parameters?
  - Differences in action selection (randomness, heuristics)
  - Mechanisms to find the value of states
  - Mechanisms of learning

- Exploit vs. Explore



- Interesting modern applications based on ('deep') RL



Mnih et al. 2015

# Course Structure

# This seminar: components

- Most of this is first time material - tell me if something doesn't work
  - Should be fun and open for suggestions
- Theory (key reference: Sutton & Barto, 1998)
- Research (key papers)
- Coding (Python)



# Dates and topics

## Options

- Just cancel
- Coding exercise
- Two sessions (coding) on 17th or 31st

Probably not around

19.04.2022

26.04.2022

03.05.2022

10.05.2022

17.05.2022

24.05.2022

31.05.2022

Holiday

14.06.2022

21.06.2022

28.06.2022

05.07.2022

12.07.2022

19.07.2022

26.07.2022

Basics,  
theory

Applications,  
other aspects

# Dates and topics

## Topics (some flexibility)

- Intro RL, Python
- Basics of learning theories, psychology
- Learning about different options, neuroscience
  - Primer on Temporal Difference (TD) learning
- Markov Decision Processes
- Basics of control
  - Dynamic Programming, TD learning
  - Action selection
- Other important aspects
  - Model-based vs. Model-free
  - Exploration vs. Exploitation

19.04.2022

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24.05.2022

31.05.2022

Basics,  
theory

# Dates and topics

## Topics (some flexibility)

- Some coding
  - Role of different parameters
  - Model-fitting
  - If possible: parameter recovery, model comparison
- ‘Advanced’ topics and current applications
  - Planning, Dyna, replay
  - Clever ways of planning, tree-search etc
- Deep RL
- Future directions, limitations, current research

14.06.2022

21.06.2022

28.06.2022

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Applications,  
important aspects

# Key resources

- Sutton and Barto 1998 Reinforcement Learning: An Introduction
- My GitHub
- Other resources
  - David Silver's course at UCL
  - Other great courses on RL in Tuebingen with slightly different focus, e.g. by Georg Martius

# Evaluation

- Some flexibility
- Essay at end of the course
  - e.g. modelling of a simple task
  - Review on specific application, topic
- Additional possibilities
  - Smaller coding exercises
  - Presentation



**What are you most interested in? Any other Ideas?**